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MDCCLXXVI.

L F H

# PREFACE.

I DO not pretend to give the origin of Fire-works, which ſome affirm were uſed in the Trojan war.

It is ſufficient for me, that they have flouriſhed a long time, and continue to do ſo in all polite nations. I am ſenſible that there are many treatiſes on this ſubject, but they are imperfect and erroneous.

I have avoided prolixity without being obſcure; my rules are plain, and I have endeavoured to lead the reader in the eaſieſt manner, from the minuteſt circumſtances to the higheſt, and have carefully kept to the ſubject. I cannot help reflecting with ſome chagrin, that, when we have theſe diverſions exhibited, we have moſtly had recourſe to foreigners; if owing to our ignorance on this ſubject, I ſhall be happy if in my power to correct them.

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# ARTIFICIAL

# FIREWORKS.

## SECT. I.—SALTPETRE.

SALTPETRE being the principal ingredient in fireworks, and a volatile body, by reaſon of its aqueous and aërial parts, is eaſily rarified by fire; but not ſo ſoon when foul and groſs, as when purified from its crude and earthy parts, which greatly retard its velocity: therefore, when any quantity of Fireworks are to be made, it ſhould be examined; for if it is not well cleanſed, and of a good ſort, your works will not have their proper effect; neither will it agree with the ſtanding proportions of compoſitions: but to prevent accidents I ſhall proceed with the method of refining it.

### To refine SALTPETRE.

Put into a copper, or any other veſſel, 100 lb. of rough nitre with 14 gallons of clean water; let it boil gently half an hour; as it boils take off the ſcum; then ſtir it, and before it ſettles put it into your filtering bags, which muſt be hung on a rack, with glazed earthen pans under them, in which muſt be ſticks laid acroſs for the cryſtals to adhere to; it muſt ſtand in the pans 2 or 3 days to ſhoot, then take out the cryſtals and let them dry: the water that remains in the pans boil again an hour, and ſtrain it into the pans as before, and the ſaltpetre will be quite clear and tranſparent;

if not, it wants more refining, to do which proceed as ufual, till it is well cleanfed of all its earthy parts.

N. B. Thofe who do not chufe to procure their faltpetre by the above method, may buy it ready done, which for fireworks in general will do.

## To pulverife SALTPETRE.

Take a copper kettle whofe bottom muft be fpherical, and put into it 14 lb. of refined faltpetre, with 2 quarts or 5 pints of clean water; then put the kettle on a flow fire, and when the faltpetre is diffolved, if any impurities arife, fkim them off, and keep conftantly ftirring it with 2 large fpatulas, till all the water exhales; and when done enough, it will appear like white fand, and as fine as flour; but if it fhould boil too faft, take the kettle off the fire, and fet it on fome wet fand, which will prevent the nitre from fticking to the kettle. When you have pulverifed a quantity of faltpetre, be careful to keep it in a dry place.

## To extract SALTPETRE from damaged GUN-POWDER.

Have fome filtering bags, hung on a rack, with glazed earthen pans under them, in the fame manner as thofe for refining faltpetre: then take any quantity of damaged powder, and put it into a copper, with as much clean water as will cover it; when it begins to boil take off the fcum, and after it has boiled a few minutes, ftir it up; then take it out of the copper with a fmall hand kettle for that purpofe, and put fome into each bag, beginning at one end of the rack, fo that by the time you have got to the laft bag, the firft will be ready for more; continue thus, till all the bags are full; then take the liquor out of the pans, which boil and filter, as before, 2 or 3 times, till the water runs quite clear, which you muft let ftand in the pans fome time,

and

and the ſaltpetre will appear at top. To get the ſaltpetre entirely out of the powder, take the water from that already extracted, to which add ſome freſh and the dregs of the powder that remain in the bags, and put them in a veſſel,. to ſtand as long as you pleaſe, and when you want to extract the nitre, you muſt proceed with this mixture as with the powder at firſt, by which means you will draw out all the ſaltpetre; but this proceſs muſt be boiled longer than the firſt.

## SULPHUR, or BRIMSTONE.

Sulphur is by nature the food of fire, and one of the principal ingredients in gunpowder, and almoſt in all compoſitions of fireworks; therefore great care muſt be taken of its being good, and brought to the higheſt perfection. To know when the ſulphur is good, you are to obſerve that it is of a high yellow, and if, when held in one's hand. it crackles and bounces, it is a ſign that it is freſh and good: but as the method of reducing brimſtone to a powder is very troubleſome, it is better to buy the flour ready made, which is done in large quantities, and in great perfection: but when a grand collection of fireworks are to be made, the ſtrongeſt and beſt ſulphur is the lump brimſtone ground in the ſame manner as gunpowder, which you will find in the following part.

## To prepare CHARCOAL for Fireworks.

Charcoal is a preſervative by which the ſaltpetre and the brimſtone is made into gun-powder, by preventing the ſulphur from ſuffocating the ſtrong and windy exhalation of the nitre. There are ſeveral ſorts of wood made uſe of for this purpoſe; ſome prefer hazle, others willow and alder; but there being ſo little difference, you may uſe either, which is moſt convenient to be got. And the method of burning it is, Cut it in pieces about 1 or 2 feet long, then ſplit each piece in 4 parts;

ſcale off the bark and hard knots, and dry them in the ſun or in an oven, then make in the earth a ſquare hole, and line it with bricks, in which lay the wood, croſſing one another, and ſet it on fire; when thoroughly lighted and in a flame, cover the hole with boards, and fling earth over them cloſe, to prevent the air from getting in, yet ſo as not to fall among the charcoal; and when it has lain thus 24 hours, take out the coals and lay them in a dry place for uſe. It is to be obſerved, that charcoal for fireworks muſt always be ſoft and well burnt, which may be bought ready done.

## To make Artificial CAMPHOR.

Camphor, in the Materia medica, "is a body of a "particular nature, being neither a reſin, a volatile "ſalt, an oil, a juice, a bitumen, or a gum, but a "mixed ſubſtance, dry, white, tranſparent and brittle, "of a ſtrong and penetrating ſmell. The Indians diſ"tinguiſh two kinds of it, a finer and a coarſer; the "finer is the produce of Borneo and Sumatra, is very "rare, and is hardly ever ſent into Europe; the coarſer "is the Japoneſe, which is the common, both in the "Indies and in Europe.

"The camphor, which we meet with in ſhops, is "alſo of 2 kinds, differing in regard to the degree "of their purity, and diſtinguiſhed by the name of "Rough and Refined. The tree, which produces cam"phor, is a ſpecies of bay tree, every part of which "abounds with camphor; but is not collected from "it in the manner of reſins, but by a ſort of chemical "proceſs.—The natives of the place where the trees "grow, cut the wood and roots into ſmall pieces, "and put them into large copper veſſels, which they "cover with earthen heads, filled with ſtraw; they "give a moderate fire under them, and the camphor is "raiſed in form of a white downy matter, and retained "among the ſtraw; when the proceſs is over, they

"ſhake

" ſhake it out of the ſtraw, and knead it into cakes. " Theſe cakes are not very compact, but eaſily crumbled to pieces; they are moderately heavy, of a " greyiſh or duſky reddiſh white in colour, of a pungent ſmell and acrid taſte, and what we call rough " camphor.

" Refined camphor muſt be choſen of a perfectly " clean white colour, very bright and pellucid, of the " ſame ſmell and taſte with the rough, but more acrid " and pungent.—It is ſo volatile that merchants uſually " incloſe it in lin-ſeed, that the viſcoſity of that grain " may keep its particles together."

There is alſo an artificial camphor for fireworks, which is made from gum ſandarach pulveriſed 2 pound, and diſtilled vinegar enough to cover it; put them in a glaſs phial, and ſet it 20 days in warm horſedung. Then take it out, and pour it into a large-mouth phial; and expoſe it to the ſun a month, and you will have a concreted camphor in form of the cruſt of bread, and ſomething like the natural camphor: which when you uſe muſt be ground to a powder with a l ttle ſpirits of wine in a mortar. Though we have here taught the method of making artificial camphor, I would not recommend it to thoſe who chuſe to make their works to perfection, the natural camphor being by far the beſt.

## To make the Oil of Camphor,

Which is ſometimes uſed to moiſten compoſitions. It is produced by adding to ſome camphor a little oil of ſweet almonds, and working them together in a braſs mortar, till it turns to a green oil.

N. B. Thoſe works that have any camphor in their compoſitions, ſhould be kept as much from air as poſſible, or the camphor will evaporate.

## Benjamin.

Benjamin is a refin (much ufed by perfumers, and fometimes in medicine); it is brought from the Indies, where it is found of different forts; and diftinguifhed by colours, viz. yellow, grey, and brown; but the beft is that which is eafy to break and full of white fpots.

Benjamin is one of the ingredients in odoriferous fire-works, when reduced to a fine flour; which may be done by putting into a deep and narrow earthen pot, 3 or 4 oz. of benjamin grofsly pounded; cover the pot with paper, which tie very clofe round the edge; then fet the pot on a flow fire, and once in an hour take off the paper, and you will find fome flour fticking to it, which return again in the pot; this you muft continue till the flour appears white and fine. There is alfo an oil of benjamin, which is fometimes drawn from the dregs of the flour; it affords a very good fcent, and may be ufed in wet compofitions.

## Origin of Gun-powder.

Gun-powder being the principal ingredient in fire-works, it is proper to give a fhort definition of its ftrange explofive force, and caufe of action, which, according to Dr. Shaw, the chemical caufe of the explofive force of gun-powder, is, "Each grain of powder confifting "of a certain proportion of fulphur, nitre, and coal, "the coal prefently takes fire, upon contact of the "fmalleft fpark: at which time both the fulphur and "the nitre immediately melt, and by means of the coal "interpofed between them, burft into flame; which "fpreading from grain to grain, propagates the fame "effect almoft inftantaneoufly: whence the whole mafs "of powder comes to be fired; and as nitre contains "both a large proportion of air and water, which are "now violently rarified by the heat, a kind of fiery

"explofive

"explosive blast is thus produced, wherein the nitre "seems, by its aqueous and aërial parts, to act as bellows to the other inflammable bodies, sulphur and "coal, to blow them into a flame, and carry off their "whole substance in smoke and vapour."

After having spoke of the nature of powder, I shall in the next place proceed to its origin, though somewhat uncertain; but it is imagined to have been invented in the time of Alexander the Great, as Philostratus speaks of a city near the river Hypasis in the Indies, that was said to be impregnable, and its inhabitants relations of the gods, because they threw thunder and lightning on their enemies; but this perhaps might be the effect of gun-powder, which, not being known to other people, might well be said to be thunder and lightning.

This conjecture has been confirmed by some travellers, who assert that it was used in the East-Indies, particularly in the Philippine Islands, about 85, which is 1265 years before it was known in Europe, where they say it was not known till 1350, though, it is said, there is mention made of gunpowder in the registers of the chambers of accounts in France, in 1338; and Friar Bacon mentions the composition of powder in express terms, in his treatise De nullitate magiae, published at Oxford in 1216; but we find from most accounts, that the Germans have the honour of the invention.

I should give a description of a machine for trying gun-powder, but they are so common, it would be needless; yet would have all who practise this art know, that, when they make sky rockets with powder, it must be of the best kind; but as to wheels, and other common works, any will do, only be careful it is quite dry.

## Compoſitions for Gun-powder of different kinds.

Having treated of the nature of powder, and its origin, I ſhall give the proportion of each ingredient, it being proper that every one who uſes powder, ſhould know of what it is compoſed Therefore, I ſhall ſet down the ſeveral compoſitions mentioned in Caſimir Siemienowicz's grand art of artillery, in which there are ſix ſorts, viz.

| | | | | |
|---|---|---|---|---|
| I. | Saltpetre 100 lb. ſulphur | 25 lb. | and coal | 25 lb. |
| II. | | 18 lb. | | 20 lb. |
| III. | | 12 lb. | | 15 lb. |
| IV. | | 20 lb. | | 24 lb. |
| V. | | 15 lb. | | 18 lb. |
| VI. | | 10 lb. | | 8 lb. |

Belidor, in his Hydraulics, ſpeaks of a compoſion for gun-powder, which is, to 30 lb. of ſaltpetre, add 5 lb. of ſulphur, with as much coal: but the proportions of the ſeveral ingredients are to be found beſt by experience. Though there has been ſo much practice in making powder, there has not yet been aſcertained a ſtanding proportion of the nitre, ſulphur, and coal; but it is hoped that in time this great and noble invention will be much improved, and that the different and beſt quantity of every ingredient will be aſcertained. At the powder mills they generally allow for waſting, in making up, 1 ½ lb. in 100. Their mixture for 100 of good powder is thus: To 76 ½ lb. of ſaltpetre, well refined and dry'd, 12 ½ lb. of coal, and as much ſulphur, which makes 101 ½ lb. which when worked up will nearly weigh 100. As gun-powder is capable of being improved, I ſhall not omit any particular that may be of ſervice to ſuch as are willing to make experiments; viz. refined ſaltpetre 5 lb. ſulphur 1 lb. 4 oz. and charcoal 7 ½ oz.

Though

Though you may have a good proportion of ingredients, the powder will not always be the ſame: much depends on their being well incorporated, corned and dry'd, the method of which will be taught in the next article.

## To reſtore damaged GUN-POWDER to its proper ſtrength.

It is certain, that, if powder is kept long in a damp place, it will become weak, and great part formed into hard lumps, a ſure ſign of its being damaged. When powder is thus found, you will ſee at the bottom of the barrel ſome ſaltpetre, which, by being wet, will ſeparate from the ſulphur and coal, and fall to the bottom of the veſſel, and ſettle in the form of a white downey matter; but the only method to prevent this, is to move the barrels as oft as convenient, and place them on their oppoſite ſides or ends: but though the greateſt care be taken, length of time will greatly leſſen its primitive ſtrength.

Therefore when any of theſe accidents happens, you may recover it by applying to theſe directions; for example, if you imagine that it has not received much damage, proceed thus. Spread it on canvas, or dry boards, and expoſe it to the ſun, then add to it an equal quantity of good powder, and mix them well, and, when thoroughly dry, barrel, and put it in a dry and proper place. But if gun-powder is quite bad, the method to reſtore it is; firſt, you muſt know what it weighed when good; then, by weighing it again, you find how much it has loſt by the ſeparation and evaporation of the ſaltpetre; then add to it as much refined ſaltpetre, as it has waſted, but as a large quantity of this would be difficult to mix, it will be beſt to put a proportion of nitre to every 20lb. of powder; when done, put one of theſe proportions into your mealing table, and grind it, till you have brought it to an impalpable powder, then ſearce it with a fine ſieve; but if any

any remain in the ſieve that will not paſs, return it t the table, and grind it again, till you have made it a fine enough to go through; being thus well ground an ſifted, it muſt be made into grains thus: firſt you mu have ſome (copper wire ſieves) made to what ſize yo intend the grains ſhould be; theſe are called cornin ſieves or grainers, which fill with the powder com poſition, then ſhake them about, and the powder wi paſs through the ſieve, formed into grains. Havin thus corned it, ſet it to dry in the ſun; and when qui dry, ſearce it with a fine hair ſieve, to ſeparate the du from the grains. This duſt may be worked with an other mixture; ſo that none will be waſted: but ſom times it may happen, that the weight when good can not be known; in which caſe add to each lb. 1 oz. o 1 ½ oz. of ſaltpetre, according as the powder is decaye and then grind, ſift, and granulate it as before.

N. B. If you have a large quantity of powder, th is very bad, and quite ſpoiled; the only way is to ex tract the ſaltpetre from it, according to the uſual man ner: for powder thus circumſtanced, will be very di ficult to recover.

## Silent Powder, commonly called Whit Powder.

It would be rather abſurd to imagine, that it is po ſible for gun-powder to have any effect without ſom report, when it is well known, that the ſound does no proceed from the powder only, but from the air bein rarified by the expanſion of it.

It is evident, that any compoſition acting with th ſame exploſive force, will produce the ſame effect, i every reſpect. Yet for ſuch I never had any proof, no ever knew any experiment made of it, but have ſo litt faith in it, that I ſhould not have given it a place i this work, had it not been treated of by ſome autho of note; and at the ſame time giving every one, wh

is fond of this art, all opportunities of making experiments, and of knowing every thing relating to it.

## To make SILENT POWDER.

For the firſt ſort, mix 2 lb. of borax, with 4 lb. of gun-powder,

2d. Add ½ lb. of lapis-calaminaris, and ½ lb. of borax, to 2 lb. of powder.

3d. To 6 lb. of gun-powder ½ lb. of calcined moles, with as much borax of Venice.

4th. To 6 ½ lb. of ſaltpetre, 8 ½ lb. of ſulphur, and ½ lb. of the ſecond bark of an elder tree, burnt and ground to a powder, with 2 lb. of common ſalt.

There are many other methods of making ſilent powder, according to report, by uſing camphor or touchwood inſtead of charcoal, or by adding to the common powder burnt paper, hay ſeed, &c. When any of theſe ingredients are to be mixed with common powder, grind them together, and make them into grains.

## GUN-POWDER of different Colours.

Notwithſtanding the repeated trials and experiments, made by the greateſt artiſts, to add to the ſtrength of gun-powder, all have proved ineffectual, and moſt have agreed that the preſent powder will not admit of a fourth ingredient: therefore it is evident, that any thing being mixed with the preſent compoſition would rather reduce its ſtrength than add to it; conſequently coloured powder muſt be weaker than black: ſo that the making of powder of different colours, is only a fancy that ſerves to pleaſe the curious, without any other effect.

## To make GUN-POWDER white.

To 6lb. of ſalt-petre, add 1 lb. of the pith of an elder tree, well dried and pulveriſed, with a ſufficient quantity

tity of brimſtone to make it into powder, which you will find in the compoſition of gun-powder, or 1 oz. of the ſalt of tartar, calcined till it comes white, and then boiled in clear water, till the water is all evaporated.

## To make POWDER red.

Boil in water ſome braſil wood or vermillion and 1 lb. of chopped paper; and, when boiled for ſome time to draw out the colour, dry and meal it with 1 lb. of ſulphur, and 8 lb of ſaltpetre.

Or, to 6 lb. of ſaltpetre, 1 lb. of ſulphur, and ½ lb. of amber, and blood ſtone 1 lb.

## To make Yellow POWDER.

Take 8 lb. of ſaltpetre, 1 lb. of ſulphur, and 1 lb. of wild ſaffron, that has been boiled in aqua vitæ, and afterwards made dry and mealed.

## To make Green POWDER.

Boil 2 lb. of rotten wood, with ſome verdegreaſe in aqua vitæ, then dry and pound it, and mix it with 1 lb. of ſulphur, and 10 lb. of ſaltpetre.

## To make Blue POWDER.

Boil ſome indigo in aqua vitæ, with 1 lb. of the bark of a young linden tree, then dry and reduce it to a powder, and mix it with 1 lb. of brimſtone, and 8 lb. of ſaltpetre.

## To make Pulvis Fulminans, or Thunder in a Room.

This compoſition is ſimple, yet has a very curious effect; it is made 3 parts of ſaltpetre, 2 of ſalt of tartar, and 1 of ſulphur, all ground to a fine powder, and well mixt. As the effect of this powder is quite different from

that

that of gun-powder, ſo is there a different method of firing it, which is thus: Put about 2 tea ſpoonfulls of it into a fire-ſhovel, or iron ladle, and ſet it over a ſlow fire, and when it is quite hot, it will go off with a violent report. There is ſomething ſurpriſing in the nature of this compoſition; for as the common powder acts every way equal, and makes the greateſt noiſe when confined, this, on the contrary, acts only downwards, and makes the ſtrongeſt report when not confined.

There is another ſort of fulminating powder, called fulminans aurum, on account of there being gold mixed in its compoſition, which is done by a chemical preparation; but as the preparing of the ingredients requires a tedious and expenſive proceſs, I ſhall omit the method of doing it, and let thoſe who chuſe to make chemical experiments refer to authors on that ſubject, by whom they will find the manner of making it. It is ſaid one grain of fulminans aurum, when made to perfection, and held on the point of a knife, over a candle, will make a report louder than a muſket.

## SECT. II.——SPUR-FIRE.

THIS fire is the moſt beautiful and curious of any yet known, and was invented by the Chineſe, but now is in greater perfection in England than in China. As it requires great trouble to make it to perfection, it will be neceſſary that beginners ſhould have full inſtructions; therefore care ſhould be taken that all the ingredients are of the beſt, that the lamp-black is not damp and clodded, that the ſaltpetre and brimſtone are thoroughly refined. This compoſition is generally rammed in 1 or 2 ounce caſes, about 5 or 6 inches long, but not drove very hard; and the caſes muſt have their concave ſtroke ſtruck very ſmooth, and the choak or vent not quite ſo large as the uſual proportion; this charge, when driven and kept a few months, will be much better than

when

when rammed, but will not ſpoil, if kept dry, in many years.

As the beauty of this compoſition cannot be ſeen at ſo great a diſtance as brilliant fire, it has a better effect in a room than in the open air, and may be fired in a chamber without any danger: it is of ſo innocent a nature, that, though with an improper phraſe, it may be called a cold fire; and ſo extraordinary is the fire produced from this compoſition, that, if well made, the ſparks will not burn a handkerchief, when held in the midſt of them; you may hold them in your hand while burning, with as much ſafety as a candle; and if you put your hand within a foot of the mouth of the caſe, you will feel the ſparks like drops of rain. When any of theſe ſpur-fires are fired ſingly, they are called artificial flower pots; but ſome of them placed round a tranſparent pyramid of paper, and fired in a large room, make a very pretty appearance.

## Compoſition for the Spur-fire.

Saltpetre 4 lb. 8 oz. ſulphur ½ lb. and lamp-black 1 lb. 8 oz.

Or, ſaltpetre 1 lb. ſulphur ½ lb. and lamp-black 4 quarts.

The ſpur-fire compoſition being very difficult to mix, and the manner of doing it quite different from any other, I ſhall here treat of it ſeparately; for example, the ſaltpetre and the brimſtone muſt be firſt ſifted together, and then put into a marble mortar, and the lamp-black with them, which you work down by degrees, with a wooden peſtle, till all the ingredients appear of one colour, which will be ſomething greyiſh, but very near black; then drive a little into a caſe for trial, and fire it in a dark place; and if the ſparks, which are called ſtars, or pinks, come out in cluſters, and afterwards ſpread well without any other ſparks, it is a ſign of its being good, otherwiſe not; for if any droſſy ſparks appear, and the ſtars not full, it is then not mixed enough; but if the pinks are very

very ſmall, and ſoon break, it is a ſign that you have rubbed it too much.

N.B. This mixture, when rubbed too much, will be too fierce, and hardly ſhew any ſtars; and, on the contrary, when not mixed enough, will be too weak, and throw out an obſcure ſmoke, and lumps of droſs, without any ſtars. The reaſon of this charge being called the ſpur-fire, is becauſe the ſparks it yields have a great reſemblance to the rowel of a ſpur, from whence it takes its name.

## Characters to the Ingredients uſed in Fireworks.

| | |
|---|---|
| Meal Powder | M |
| Corned Powder | ɘ |
| Saltpetre | θ |
| Brimſtone | Ƶ |
| Crude Sulphur | C Ƶ |
| Charcoal | C + |
| Sea Coal | C S |
| Saw-duſt or Beech-raſpings | B R |
| Steel or Iron filings | S × |
| Braſs duſt | B × |
| Glaſs duſt | G × |
| Tanners duſt of Bark | T × |
| Caſt Iron | C I |
| Antimony Crude | C A |
| Camphor | × |
| Yellow Amber | A Y |
| Lapis Calaminaris | L S |
| Gum | ⌒ |
| Lamp Black | B L |
| Iſing Glaſs | G I |
| Spirit of Wine | W |
| Spirits of Turpentine | S T |
| Oil of Spike | PO |

Their uſe is, that by them the receipts may be contracted, ſo that they may be contained in a leaf of a pocket book, which is much leſs than any table that has yet been invented. And they are convenient for travellers.

## To meal Gun-powder, Brimstone, and Charcoal.

There have been many methods uſed to grind theſe ingredients to a powder for fireworks, ſuch as large mortars and peſtles, made of ebony, and other hard wood; and horizontal mills with braſs barrels; but none have proved ſo effectual and ſpeedy as the laſt invention, that of the mealing table, repreſented in Plate I. Fig. I. made of elm, with a rim round its edge, 4 or 5 inches high; and at the narrow end, A, is a ſlider, that runs in a groove and forms part of the rim; ſo that when you have taken out of the table, as much powder as you can, with the copper ſhovel Fig. 2. ſweep all clean out at the ſlider A. When you are going to meal a quantity of powder, obſerve not to put too much in the table at once; but when you have put in a good proportion, take the muller, Fig. 3. and rub it till all the grains are broke; then ſearce it, in a lawn ſieve that has a receiver and top to it; and that which does not paſs through the ſieve, return again to the table and grind it, till you have brought it all fine enough to go through the ſieve. Brimſtone and charcoal are ground in the ſame manner, only the muller muſt be made of ebony; for theſe ingredients, being harder than powder, would ſtick in the grain of elm, and be difficult to grind; as brimſtone is apt to ſtick and clod to the table, it will be beſt to keep one for that purpoſe, by which means you will always have your brimſtone clean and well ground.

To

## To prepare Cast-Iron for Gerbes, White Fountains, and Chinese Fire.

Cast-iron being of so hard a nature, as not to be cut by a file, we are obliged to reduce it into grains, though somewhat difficult to perform; but if we consider what beautiful sparks this sort of iron yields, no pains should be spared to granulate such an essential material, to do which, get at an iron foundry some thin pieces of iron, such as generally runs over the moulds at the time of casting: then have a square block made of cast iron, and an iron square hammer about 4 lb. weight; then, having covered the floor with cloth, or something to catch the beatings, lay the thin pieces of iron on the block, and beat them with the hammer, till reduced into small grains, which afterwards searce with a very fine sieve, to separate the fine dust, which is sometimes used in small cases of brilliant fire, instead of steel dust; and when you have got out all the dust, sift what remains with a sieve a little larger, and so on with sieves of different sizes, till the iron passes through about the bigness of small bird shot: your iron thus beat and sifted, put each sort into wooden boxes or oiled paper, to keep it from rusting. When you use it, observe the difference of its size, in proportion to the cases for which the charge is intended; for the coarse sort is only designed for very large gerbes, of 6 or 8 lb.

## Charges for Sky-Rockets, &c.

### Rockets of Four Ounces.

Mealed powder 1 lb. 4 oz. saltpetre 4 oz. and charcoal 2 oz.

## Rockets of Eight Ounces.

I. Mealed powder 1 lb. faltpetre 4 oz. brimftone 3 oz. and charcoal 1 oz. and ½.

II. Meal powder 1 lb. and ½, and charcoal 4 oz. and ½.

## Rockets of One Pound.

Meal powder 2 lb. faltpetre 8 oz. brimftone 4 oz. charcoal 2 oz. and fteel filings 1 oz. and ½.

## Sky Rockets in general.

I. Saltpetre 4 lb. brimftone 1 lb. and charcoal 1 lb. ½.

II. Saltpetre 4 lb. brimftone 1 lb. ½. charcoal 1 lb. 12 oz. and meal powder 2 oz.

## Large Sky Rockets.

Saltpetre 4 lb. meal powder 1 lb. and brimftone 1 lb.

## Compofitions to be ufed in Rockets of a middling fize.

I. Saltpetre 8 lb. fulphur 3 lb. meal powder 3 lb.

II. Saltpetre 3 lb. fulphur 2 lb. meal powder 1 lb. charcoal 1 lb.

## Compofitions for Rocket Stars.

### White Stars.

Meal powder 4 oz. faltpetre 12 oz. fulphur vivum 6 oz. oil of fpike 2 oz. and camphor 5 oz.

### Blue Stars.

Meal powder 8 oz. falpetre 4, fulphur 2, fpirits of wine 2, and oil of fpike 2.

Coloured

## Coloured, or variegated Stars.

Meal powder 8 drams, rochpetre 4 oz. sulphur vivum 2, and camphor 2.

## Brilliant Stars.

Saltpetre 3 ½ oz. sulphur 1 ½, and meal powder ¾, worked up with spirits of wine only.

## Common Stars.

Saltpetre 1lb. brimstone 4 oz. antimony 4 ½, isinglass ½, camphor ½, and spirits of wine ¾.

## Tailed Stars.

Meal powder 3 oz. brimstone 2, saltpetre 1½ and charcoal (coarsely ground) ½.

## Drove Stars.

I. Saltpetre 3lb. sulphur 1lb. brass dust 12 oz. antimony 3.

II. Saltpetre 1lb. antimony 4 oz. and sulphur 8.

## Fixed Pointed Stars.

Saltpetre 8 ½ oz. sulphur 2, antimony 1 oz. 10 dr.

## Stars of a Fine Colour.

Sulphur 1 oz. meal powder 1, saltpetre 1, camphor 4 dr. oil of turpentine 4 dr.

## Gold Rain for Sky Rockets.

I. Saltpetre 1 lb. meal powder 4 oz. sulphur 4, brass dust 1, saw dust 2 ¼, and glass dust 6 dr.

II. Meal powder 12 oz. saltpetre 2, charcoal 4.

III. Saltpetre 8 oz. brimstone 2, glass dust 1, antimony ½, brass dust ½, and saw dust 12 dr.

## Silver Rain.

I. Saltpetre 4 oz. sulphur, meal powder, and antimony, of each 2 oz. sal prunella ½ oz.

II. Saltpetre ½lb. brimstone 2 oz. and charcoal 4.

III. Saltpetre 1lb. brimstone ½lb. antimony 6 oz.

IV. Saltpetre 4 oz. brimstone 1, powder 2, and steel dust ¾ oz.

## Water Rockets.

I. Meal powder 6lb. saltpetre 4, brimstone 3, charcoal 5.

II. Saltpetre 1lb. brimstone 4½ oz. charcoal 6.

III. Saltpetre 1lb. brimstone 4 oz. charcoal 12 oz.

IV. Saltpetre 4lb. brimstone 1lb. 8 oz. charcoal 1lb. 12 oz.

V. Brimstone 2lb. saltpetre 4lb. and meal powder 4.

VI. Saltpetre 1lb. meal powder 4 oz. brimstone 8 ½, charcoal 2.

VII. Meal powder 1lb. saltpetre 3, brimstone 1. seacoal 1 oz. charcoal 8½, saw dust ½, steel dust ¼, and coarse charcoal ¼ oz.

VIII. Meal powder 1½lb. saltpetre 3, sulphur 1½, charcoal 12 oz. saw dust 2.

## Sinking Charge for Water Rockets.

Meal powder 8 oz. charcoal ½ oz.

## Wheel Cases from 2 oz. to 4lb.

I. Meal powder 2lb. saltpetre 4 oz. iron filings 7.

II. Meal powder 2lb. saltpetre 12 oz. sulphur 4, steel dust 3.

III. Meal powder 4lb. saltpetre 1lb. brimstone 8 oz. charcoal 4 ½.

IV. Meal powder 8 oz. ſaltpetre 4, ſaw duſt 1½, ſea-coal ¾.

V. Meal powder 1lb. 4 oz. brimſtone 4 oz. 10 dr. ſaltpetre 8 oz. glaſs duſt 2½.

VI. Meal powder 12 oz. charcoal 1, ſaw duſt ½.

VII. Saltpetre 1lb. 9 oz. brimſtone 4 oz. charcoal 4½.

VIII. Meal powder 2lb. ſaltpetre 1, brimſtone ½, and ſeacoal 2 oz.

IX. Saltpetre 2lb. brimſtone 1, meal powder 4, and glaſs duſt 4 oz.

X. Meal powder 1lb. ſaltpetre 2 oz. and ſteel duſt 3½.

XI. Meal powder 2lb. and ſteel duſt 2½ oz. with 2½ of the fine duſt of beat iron.

XII. Saltpetre 2lb. 13 oz. brimſtone 8 oz. and charcoal 6.

## Slow Fire for Wheels.

I. Saltpetre 4 oz. brimſtone 2, and meal powder 1½.

II. Saltpetre 4 oz. brimſtone 1, and antimony 1 oz. 6 dr.

III. Saltpetre 4½ oz. brimſtone 1 oz. and mealed powder 1½.

## Dead Fire for Wheels.

I. Saltpetre 1¼ oz. brimſtone ¼, lapis-calaminaris ¼, and antimony 2 dr.

## Standing or fixed Caſes.

I. Meal powder 4lb. ſaltpetre 2, brimſtone and charcoal 1.

II. Meal powder 2lb. ſaltpetre 1, and ſteel duſt 8 oz.

III. Meal powder 1lb. 4 oz. and charcoal 4 oz.

IV. Meal powder 1lb. and ſteel duſt 4 oz.

V. Meal powder 2½lb. brimſtone 4 oz. and ſea coal 6.

VI. Meal powder 3 lb. charcoal 5 oz. and ſaw duſt 1½.

## Sun Cases.

I. Meal powder 8 ½lb. saltpetre 1lb. 2 oz. steel dust 2lb. 10½ oz. brimstone 4.

II. Meal powder 3lb. saltpetre 6 oz. and steel dust 7½.

## A Brilliant Fire.

Meal powder 12lb. saltpetre 1, brimstone 4 oz. steel dust 1 ½lb.

## Gerbes.

Meal powder 6lb. and beat iron 2lb. 1 ½ oz.

## Chinese Fire.

Saltpetre 12 oz. mealpowder 2lb. brimstone 1lb. 2 oz. and beat iron 12 oz.

## Charge for Four-ounce Tourbillons.

Meal powder 2lb. 4 oz. and charcoal 4 ½ oz.

## Eight-ounce Tourbillons.

Meal powder 2lb. and charcoal 4 ¾ oz.

## Large Tourbillons.

Meal powder 2lb. saltpetre 1, brimstone 8 oz. and beat iron 8.

N. B. Tourbillons may be made very large, and of different colour'd fires; only you are to observe, that the larger they are, the weaker must be the charge; and, on the contrary, the smaller, the stronger their charge.

## Water Ballóóns.

I. Saltpetre 4lb. brimstone 2, meal powder 2, antimony 4 oz. saw dust 4, and glass dust 1 ½.

II.

II. Saltpetre 9 lb. brimstone 3 lb. meal powder 6 lb. rosin 12 oz. and antimony 8 oz.

## Water Squibs.

I. Meal powder 1 lb. and charcoal 1 lb.

II. Meal powder 1 lb. and charcoal 9 oz.

## Mine Ports or Serpents.

I. Meal powder 1 lb. and charcoal 1 oz.

II. Meal powder 9 oz. charcoal 1 oz.

## Port-fires for firing Rockets, &c.

I. Saltpetre 12 oz. brimstone 4 oz. and meal powder 2 oz.

II. Saltpetre 8 oz. brimstone 4 oz. and meal powder 2 oz.

III. Saltpetre 1 lb. 2 oz. meal powder 1 ½ lb. and brimstone 10 oz. This composition must be moistened with one gill of linseed oil.

IV. Meal powder 6 oz. saltpetre 2 lb. 2 oz. and brimstone 10 oz.

V. Saltpetre 1 lb. 4 oz. meal powder 4 oz. brimstone 5 oz. saw dust 8 oz.

VI. Saltpetre 8 oz. brimstone 2 oz. and meal powder 2 oz.

## Port-fires for Illuminations.

Saltpetre 1 lb. brimstone 8 oz. and meal powder 6 oz.

## Cones or Spiral Wheels.

Saltpetre 1 lb. brimstone 6 oz. meal powder 12 oz. and glass dust 14 oz.

## Crowns, or Globes.

Saltpetre 6 oz. brimstone 2 lb. antimony 4 oz. and camphor 2 oz.

Air

## Air Balloon Fuzes.

I. Saltpetre 1 lb. 10 oz. brimſtone 8 oz. and meal powder 1 lb. 6 oz.

II. Saltpetre 1 ½ lb. brimſtone 8 oz. and meal powder 1 lb. 8 oz.

## Serpents for Pots des Brins.

Meal powder 1 lb. 8 oz. ſaltpetre 12 oz. and charcoal 2 oz.

## Fire Pumps.

I. Saltpetre 5 lb. brimſtone 1 lb. meal powder 1 ½ lb. and glaſs duſt 1 lb.

II. Saltpetre 5 lb. 8 oz. brimſtone 2 lb. meal powder 1 lb. 8 oz. and glaſs duſt 1 lb. 8 oz.

## A Slow White Flame.

I. Saltpetre 2 lb. ſulphur 3 lb. antimony 1 lb.

II. Saltpetre 3 ½ lb. ſulphur 2 ½ lb. meal powder 1 lb. antimony ½ lb. glaſs duſt 4 oz. braſs duſt 1 oz.

N. B. Theſe compoſitions, driven 1 ¾ inch in a 1 oz. caſe, will burn 1 minute, which is much longer time than an equal quantity of any compoſition, yet known, will laſt.

## Amber Lights.

Meal powder 9 oz. amber 3 oz. This charge may be drove in ſmall caſes, for illuminations.

## Lights of another Kind.

Saltpetre 3 lb. brimſtone 1 lb. meal powder 1 lb. antimony 10 ½ oz. All theſe muſt be mixed with the oil of ſpike.

## A Red Fire.

Meal powder 3 lb. charcoal 12 oz. and ſaw duſt 8 oz.

## A Common Fire.

Saltpetre 3 lb. charcoal 10 oz. and brimſtone 2 oz.

## To make an Artificial Earthquake.

Mix the following ingredients to a paſte with water, and then bury it in the ground, and in a few hours the earth will break and open in ſeveral places. The compoſition: Sulphur 4 lb. and ſteel duſt 4 lb.

Having laid down, under the preceding heads, the different compoſitions uſed in fireworks by our modern artiſts; I ſhall, in the next place, give ſome tables of charges that were formerly uſed, according to the ſeveral accounts given by thoſe authors from whom they are collected: but if the reader will conſider, he will find the charges in theſe tables to be very uncertain, by comparing their method of determining the ſize and weight of rockets, and the proportions of ingredients thereto, with the method taught in this work, which is ſo plain, eaſy, and certain, that I never yet knew it fail; and doubt not, but that it will be ſo allowed by all who chuſe to make the trial.

The ſubſequent table is taken from Siemienowicz, wherein are ſpecified the different charges of ſky rockets, from ½ oz. to 100 lb.; the charges being calculated in proportion to the weight of a leaden ball of the ſame diameter as the bore of each mould; which bores are divided into inches and lines,* and each line into 12 parts, according to the French method.

* A line is the 12th part of an inch.

TAB. I.

# TAB. I.

## Charges for Rockets, &c.

| Ball's weight. | | Mould's diam. | | | Powder. | | Saltpetre. | | Brimstone. | | Charcoal. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lb. | oz. | in. | l. | pts. | lb. | oz. | lb. | oz. | lb. | oz. | lb. | oz. |
| | ½ | 0 | 6 | 3 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 2 |
| | 1 | 0 | 7 | 8 | | | | | | | | |
| | 2 | 0 | 9 | 7 | 0 | 12 | 0 | 2 | 0 | ½ | 0 | 1½ |
| | 3 | 0 | 11 | 0 | | | | | | | | |
| | 4 | 1 | 0 | 1 | | | | | | | | |
| | 5 | 1 | 1 | 0 | 1 | 3 | 0 | 12 | 0 | 4 | 0 | 1½ |
| | 6 | 1 | 1 | 10 | | | | | | | | |
| | 7 | 1 | 2 | 7 | | | | | | | | |
| | 8 | 1 | 3 | 4 | | | | | | | | |
| | 9 | 1 | 3 | 11 | | | | | | | | |
| | 10 | 1 | 4 | 5 | | | | | | | | |
| | 11 | 1 | 5 | 0 | | | | | | | | |
| | 12 | 1 | 5 | 5 | | | | | | | | |
| | 13 | 1 | 6 | 0 | | | | | | | | |
| | 14 | 1 | 6 | 5 | | | | | | | | |
| | 16 | 1 | 7 | 3 | 18 | 0 | 8 | 0 | 2 | 0 | 4 | 0 |
| 2 | 0 | 2 | 0 | 3 | 0 | 0 | 60 | 0 | 2 | 0 | 15 | 0 |
| 3 | 0 | 2 | 3 | 7 | | | | | | | | |
| 4 | 0 | 2 | 6 | 9 | 0 | 0 | 64 | 0 | 8 | 0 | 16 | 0 |
| 5 | 0 | 2 | 8 | 8 | | | | | | | | |
| 6 | 0 | 2 | 10 | 9 | 0 | 0 | 35 | 0 | 5 | 0 | 10 | 0 |
| 8 | 0 | 3 | 2 | 6 | | | | | | | | |
| 10 | 0 | 3 | 5 | 4 | 0 | 0 | 62 | 0 | 9 | 0 | 20 | 0 |
| 12 | 0 | 3 | 7 | 10 | 0 | 0 | 32 | 0 | 8 | 0 | 16 | 0 |
| 15 | 0 | 3 | 11 | 4 | | | | | | | | |
| 17 | 0 | 4 | 1 | 5 | 0 | 0 | 64 | 0 | 12 | 0 | 16 | 0 |
| 20 | 0 | 4 | 4 | 2 | | | | | | | | |
| 27 | 0 | 4 | 9 | 9 | | | | | | | | |
| 30 | 0 | 4 | 11 | 6 | 0 | 0 | 30 | 0 | 7 | 0 | 18 | 0 |
| 40 | 0 | 5 | 5 | 1 | | | | | | | | |
| 60 | 0 | 6 | 3 | 3 | 0 | 0 | 30 | 0 | 10 | 0 | 20 | 0 |
| 100 | 0 | 7 | 5 | 3 | | | | | | | | |

TAB.

# TAB. II.

## Rocket, &c. Charges.

From a late French author*, who regulated his charges according to the interior diameter of the mould, divided into lines.

| Interior diameter of the mould. | Rocket's Weight. | | | Saltpetre. | Brimstone. | Charcoal. |
|---|---|---|---|---|---|---|
| Lines. | lb. | oz. | dr. | ounces. | ounces. | ounces. |
| 6 | 0 | 0 | 4 | | | |
| 7 | 0 | 0 | 6 | 44 | 4 | 16 |
| 8 | 0 | 1 | 1 | | | |
| 9 | 0 | 1 | 5 | | | |
| 10 | 0 | 2 | 2 | 40 | 4 | 16 |
| 11 | 0 | 3 | 0 | | | |
| 12 | 0 | 3 | 7 | | | |
| 13 | 0 | 4 | 6 | 38 | 4 | 16 |
| 14 | 0 | 6 | 1 | | | |
| 15 | 0 | 7 | 4 | | | |
| 16 | 0 | 9 | 1 | 36 | 4 | 16 |
| 17 | 0 | 11 | 0 | | | |
| 18 | 0 | 13 | 1 | | | |
| 19 | 0 | 15 | 4 | 34 | 4 | 16 |
| 19¾ | 1 | 0 | 0 | | | |
| 21 | 1 | 7 | 1 | | | |
| 24 | 1 | 15 | 1 | 32 | 5 | 16 |
| 30 | 4 | 0 | 0 | | | |
| 36 | 6 | 9 | 0 | 30 | 6 | 18 |
| 72 | 55 | 8 | 0 | | | |

* Traité des feux d'artifice, par M. F***.

TAB.

## TAB. III.

### SKY-ROCKETS.

The charges adapted to the weight of composition in each, after Hanzelet's method.

| Composition Wt. | Powder | Saltpetre. | Brimstone. | Charcoal. |
|---|---|---|---|---|
| lb. oz. | lb. oz. | lb. oz. | lb. oz. | lb. oz. |
| 0 1½ | 0 4 | | | 0 1 |
| or, | 1 0 | 0 1½ | | 0 1½ |
| 0 2 | 0 4 | 0 1 | | |
| or, | 0 4 | | | 0 ½ |
| 0 4 } 0 8 } | 1 0 | 0 4 | | 0 4 |
| or, | 0 3 | 0 10 | 0 1 | 0 3 |
| | 0 10 | 0 3½ | 0 1 | 0 3½ |
| 1 0 | 1 0 | | 0 1 | 0 2 |
| or, | | 1 4 | 0 2 | 0 3½ |
| 3 0 | | 1 14 | 7 7½ | 0 11 |
| 6 0 } 7 0 } | | 31 0 | 4 8 | 10 0 |
| 8 0 } 10 0 } | | 8 0 | 1 8 | 2 12 |

TAB.

# T A B. IV.

From Henrion, whoſe method is as in the preceding.

| Compoſition Wt. | Powder | Saltpetre. | Brimſtone. | Charcoal. |
|---|---|---|---|---|
| lb. oz. | lb. oz. | lb. oz. | lb. oz. | lb. oz. |
| 1 | | | | |
| 2 | 1 0 | | | 0 2 |
| or, | 1 0 | 1 0 | | 0 1 |
| 3 | 4½ | 0 1 | | 0 1 |
| 4<br>8 | 4 0 | 1 0 | 0 ½ | 0 4 |
| | 1 8 | 0 4 | | 0 2 |
| or, | 1 0 | 0 4 | | 0 1 |
| | 3 ½ | 0 10 | | 0 3½ |
| 8<br>10 | 2 5 | 0 0 | 0 2<br>ſteel duſt<br>0 2 | 0 6 |
| 12 | 17 0 | 0 4 | 0 3½ | 0 7 |
| 14<br>15 | 2 8 | 0 9 | 0 3<br>ſteel duſt<br>0 3 | 0 3 |
| 1 0 | 1 0 | 0 0 | 0 1 | 0 3 |
| 2 0 | 0 2 | 0 12 | 0 1 | 0 3 |
| 3 0<br>10 0 | 0 0 | 8 0 | 1 4<br>ſteel duſt<br>0 2 | 2 2 |

TAB.

## TAB. V.

### Charges for Sky-Rockets,

From M. de Saint Remy, improved by M. F***.

| | | | | | |
|---|---|---|---|---|---|
| Composition for a Rocket of | | | | | |
| 2 lb. | 1 lb. | ½ lb. | 4 oz. | 1 ½ oz. | |
| CORRECTED | | | | | |
| By M. F***, 1lb. | 11 oz. | 7 ½ oz. | 6 oz. 5dr. | 1 oz. 5 dr. | |
| lb. oz. | lb. oz. | lb. oz. | oz. | oz. | |
| Pow. 2 0 | 1 0 | 1 4 | 5 | 8 or 9 | |
| Saltp. 1 0 | 12 | 12 | 1 | $\frac{1}{5}$ | |
| Brimst. 5 | 2 | 1 | ¼ | | |
| Charc. 4 | | 3 | ½ | ½ or 1 | |
| Steel-d. 2 | | 2 | | | |
| Mould Height, in Inches. | | | | | |
| 9 ½ in. | 8 ½ | 7 ½ | 7 | 4 ½ | |
| Diameter, in Inches and Lines. | | | | | |
| 1 in. 7 l. | 1 5 | 1 3 | 1 2 | 9 lines | |
| French Names for Sky Rockets. | | | | | |
| Double Marquise. | Marquise. | Grosse departement | Departement. | Fusie de Caisse | |

Remarks

## Remarks on the foregoing Tables.

In the firſt, we find that the compoſitions for all rockets under 1 lb. are made chiefly of gunpowder and charcoal, which method has been long proved erroneous in many reſpects: firſt, that rockets made with ſuch charges will not keep long without ſpoiling; ſecondly, that they are very uncertain in performing their proper effect; thirdly, they will carry but a ſhort tail, with a black and ſmoaky fire.

We alſo find thoſe charges for rockets above 1 lb., that are compoſed of ſaltpetre, brimſtone, and charcoal, to be too ſtrong; by which we ſhould imagine that, at the time when they were uſed, the piercers did not bear the ſame proportion to the rockets, as thoſe uſed by our preſent artiſts; as it is on the ſize of the cavity in the compoſition, that the effect of the rocket and proportion of the charge depends: which I ſhall endeavour to ſhew hereafter.

Table II. is given, by the author, as an improvement on the firſt; wherein he takes notice of the charges being too many in number; he has therefore reduced them to 7, which, according to his opinion, are ſufficient for rockets of any ſize: he alſo obſerves, that the ingredients are expreſſed in unequal quantities; which he has likewiſe laid down in a more regular order. By the ſame author's account, rockets were made in France, not many years ſince, with the compoſitions mentioned in his table. I ſhall not here pretend to ſay, that rockets were not made with the charges given in the ſaid table; yet can affirm, by experience, that ſeveral of them will not agree with our preſent moulds.

As to the method preſcribed in tables III. and IV. it is difficult to determine whether we ſhall praiſe or condemn them, as they were wrote when the art of making fireworks was in its infancy; as may be ſeen by their ſtrange method of determining the proportion of ingredients,

dients, and weight of rockets, by the quantity of composition contained in each caſe; which muſt have required a very nice calculation; for at that time they had not fixed upon an exact length for rockets, but made them from 6 to 9 diameters long: all which differ ſo much from our modern practice, that I never thought it worth the trouble of making a trial; but am of opinion, that very few of the charges will anſwer.

In the fifth Table, the compoſitions are in proportion to the weight of the rocket, with its head and ſtick, all complete; which head and ſtick are equal to the weight of the rocket, according to the improvement made by M. F***, as in the ſecond column from the top: he has alſo added the diameters to the moulds, in proportion to their height, allowing each 6 diameters, which ſuppoſing to be right, the rockets will be nearly reduced to ½ their weight given in the firſt column. On the charges in this table I have made no experiment, therefore cannot recommend them as proof.

Having given a variety of c...ges for ſky-rockets, in the preceding tables, which are collected from the principal authors on this ſubject, together with remarks, I ſhall, in the next place, according to my promiſe of not omitting any thing that may be of ſervice to the reader, add ſome compoſitions for rocket-ſtars of ſeveral colours, as inſerted by former authors.

## Compoſitions for Stars of different Colours.

I. Meal powder 4 oz. ſaltpetre 2 oz. brimſtone 2 oz. ſteel duſt 1 ½ oz. and camphor, white amber, antimony, and mercury-ſublimate, of each ½ oz.

II. Rochepetre 10 oz. brimſtone, charcoal, antimony, meal powder, and camphor, of each ¾ oz. moiſtened with oil of turpentine. Theſe compoſitions are made into ſtars, by being worked to a paſte with aqua vitæ, in which has been diſſolved ſome gum-tragacanth; and after you have rolled them in powder, make a hole through the middle of each, and ſtring them on quickmatch, leaving about 2 inches between each.

III

III. Saltpetre 8 oz. brimſtone 2 oz. yellow amber 1 oz. antimony 1 oz. and powder 3 oz.

IV. Brimſtone 2 ½ oz. ſaltpetre 6 oz. olibanum or frankincenſe in drops 4 oz.; maſtick, and mercury-ſublimate, of each 4 oz. meal powder 5 oz. white amber, yellow amber, and camphor, of each 1 oz. antimony and orpiment ¼ oz. each.

V. Saltpetre 1 lb. brimſtone ½ lb. and meal powder 8 oz. moiſtened with potrolio-oil.

VI. Powder ½ lb. brimſtone and ſaltpetre, of each 4 oz.

VII. Saltpetre 4 oz. brimſtone 2 oz. and meal powder 1 oz.

## Stars that carry Tails of Sparks.

I. Brimſtone 6 oz. antimony crude 2 oz. ſaltpetre 4 oz. and roſin 4 oz.

II. Saltpetre, roſin, and charcoal, of each 2 oz. brimſtone 1 oz. and pitch 1 oz.

Theſe compoſitions are ſometimes melted in an earthen pan, and mixed with chopped cotton-match, before they are rolled into ſtars, but will do as well if wetted, and worked up in the uſual manner.

## Stars that yield ſome Sparks.

I. Camphor 2 oz. ſaltpetre 1 oz. meal powder 1 oz.

II. Saltpetre 1 oz. ditto melted ¼ oz. and camphor 2 oz. When you would make ſtars of either of theſe compoſitions, you muſt wet them with gum water, or ſpirit of wine, in which has been diſſolved ſome gum-arabick, or gum-tragacanth, that the whole may have the conſiſtence of a pretty thick liquid; having thus done, take 1 oz. of lint, and ſtir it about in the compoſition till it becomes dry enough to roll into ſtars.

## Stars of a yellowiſh Colour.

Take 4 oz. of gum-tragacanth or gum-arabick, pounded and ſifted through a fine ſieve, camphor diſſolved

in brandy 2 oz. ſaltpetre 1 lb. ſulphur ½ lb. coarſe powder of glaſs 4 oz. white amber 1 ½ oz. orpiment 2 oz. Being well incorporated, make them into ſtars after the common method.

## Stars of another Kind.

Take 1 lb. of camphor, and melt it in a pint of ſpirit of wine over a ſlow fire; then add to it 1 lb. of gum-arabick that has been diſſolved; with this liquor mix 1 lb. of ſaltpetre, 6 oz. of ſulphur, and 5 oz. of meal powder; and after you have ſtirred them well together, roll them into ſtars proportionable to the rockets for which you intend them.

## Colours produced by the different Compoſitions.

As variety of fires adds greatly to a collection of works, it is neceſſary that every artiſt ſhould know the different effect of each ingredient; for which reaſon, I ſhall here explain the colours they produce of themſelves; and likewiſe how to make them retain the ſame when mixed with other bodies: as for example, ſulphur gives a blue, camphor a white or pale colour, ſaltpetre a clear white, yellow amber a colour inclining to yellow, ſal-armoniac a green, antimony a reddiſh, roſin a copper colour, and greek-pitch a kind of bronze or between red and yellow. All theſe ingredients are ſuch as ſhew themſelves in a flame, viz.

## White Flame.

Saltpetre, ſulphur, meal powder, and camphor; the ſaltpetre muſt be the chief part.

## Blue Flame.

Meal powder, ſaltpetre, and ſulphur vivum; ſulphur muſt be the chief: or, meal powder, ſaltpetre, brimſtone,

ftone, fpirit of wine, and oil of fpike; but let the powder be the principal part.

## Flame inclining to Red.

Saltpetre, fulphur, antimony, and greek-pitch; faltpetre the chief.

By the above method may be made various colours of fire, as the practitioner pleafes; for, by making a few trials, he may caufe any ingredient to be predominan in colour.

## Ingredients that fhew in Sparks when rammed in choaked Cafes.

The fet colours of fire produced by fparks are divided into 4 forts, viz. the black, white, grey, and red: the black charges are compofed of 2 ingredients, which are meal powder and charcoal; the white of 3, viz. faltpetre, fulphur, and charcoal; the grey of 4, viz. meal powder, faltpetre, brimftone, and charcoal; and the red of 3, viz. meal powder, charcoal, and faw duft.

There are, befides thefe 4 regular or fet charges, 2 others, which are diftinguifhed by the names of compound and brilliant charges; the compound being made of many ingredients, fuch as meal powder, faltpetre, brimftone, charcoal, faw duft, fea-coal, antimony, glafs duft, brafs duft, fteel filings, caft iron, tanner's duft, &c. or any thing that will yield fparks; all which muft be managed with difcretion. The brilliant fires are compofed of meal powder, faltpetre, brimftone, and fteel duft; or with meal powder and fteel filings only.

## Cotton Quick-match

Is generally made of fuch cotton as is put in candles, of feveral fizes, from 1 to 6 threads thick, according to the pipes it is defigned for, which pipe muft

be large enough for the match, when made, to be puſhed in eaſily without breaking it. Having doubled the cotton into as many threads as you think proper, coil it very lightly into a flat-bottomed copper or earthen pan; then put in the ſaltpetre and the liquor, and boil them about 20 minutes; after which coil it again into another pan, as in Fig. 4. and pour on it what liquor remains; then put in ſome meal powder, and preſs it down with your hands, till it is quite wet; afterwards place the pan before the wooden frame, Fig. 5. which muſt be ſuſpended by a point in the centre of each end; and place yourſelf before the pan, tying the upper end of the cotton to the end of 1 of the ſides of the frame.

When every thing is ready, you muſt have one to turn the frame round, while you let the cotton paſs through your hands, holding it very lightly, and at the ſame time keeping your hands full of the wet powder; but if the powder ſhould be too wet to ſtick to the cotton, put more in the pan, ſo as to keep a continual ſupply till the match is all wound up; you may wind it as cloſe on the frame as you pleaſe, ſo that it does not ſtick together; when the frame is full, take it off the points, and ſift dry meal powder on both ſides the match, till it appears quite dry: in winter the match will be a fortnight before it is fit for uſe; when it is thoroughly dry, cut it along the outſide of one of the ſides of the frame, and tie it up in ſkains for uſe.

N. B. The match muſt be wound tight on the frames.

## Ingredients for the Match.

Cotton 1 lb. 12 oz. ſaltpetre 1 lb. ſpirit of wine 2 quarts, water 3 quarts, iſinglaſs 3 gills, and meal powder 10 lb. To diſſolve 4 oz. of iſinglaſs, take 3 pints of water.

SECT.

## SECT. III.—Sky-rocket Moulds.

AS the performance of rockets depends much on their moulds, it is requisite to give a definition of them and their proportions: They are made and proportioned by the diameter of their orifice, which are divided into = parts: as Fig 6. represents a mould made by its diameter AB, its height from C to D is 6 diameters and 2 thirds; from D to E is the height of the foot, which is 1 diameter and 2 thirds; F the choak, or cylinder, whose height is 1 diameter and 1-3d; it must be made out of the same piece as the foot, and fit tight in the mould; G an iron pin that goes through the mould and cylinder, to keep the foot fast; H the nipple, which is ½ a diameter high, and 2-3ds thick, and of the same piece of metal as the piercer I, whose height is 3 ½ diameters, and at the bottom is 1 3d of the diameter thick, and from thence tapering to 1-6th of the diameter: the best way to fix the piercer in the cylinder, is to make that part below the nipple long enough to go quite through the foot, and rivet it at bottom. Fig. 7. is a former or roller for the cases, whose length, from the handle, is 7 ½ diameters, and its diameter 2-3ds of the bore AB; 8. the end of the former, which is of the same thickness, and 1 diameter and 2-3ds long; the small part, which fits into the hole in the end of the roller when the case is pinching, is 1 6th and ½ of the mould's diameter thick. Fig. 9. the first drift, which must be 6 diameters from the handle, and this as well as all other rammers must be a little thinner than the former, to prevent the sacking of the paper, when you are driving in the charge: in the end of this rammer is a hole to fit over the piercer; the line K marked on this is 2 diameters and 1-3d from the handle; so that, when you are filling the rocket, this line appears at top of the case; you must then take the 2d rammer, 10. which from

from the handle is 4 diameters; and the hole for the piercer is 1 ½ diameter long. Fig 11. is the ſhort and ſolid drift which you uſe when you have filled the caſe as high as the top of the piercer.

Rammers muſt have a collar of braſs at the bottom, to keep the wood from ſpreading or ſplitting; and that the ſame proportion be given to all moulds, from 1 oz. to 6 lb. I mentioned nothing concerning the handles of the rammers; however, if their diameter be equal to the bore of the mould, and 2 diameters long, it will be a very good proportion; but the ſhorter you can uſe them, the better; for the longer the drift, the leſs will be the preſſure on the compoſition, by the blow given with the mallet.

## Dimenſions for Rocket Moulds, in which the Rockets are rammed ſolid.

| Weight of rockets. | Length of the moulds without their feet. | Interior diameter of the moulds | Height of the nipples. |
|---|---|---|---|
| lb. oz. | Inches | Inches. | Inches |
| 6 0 | 34,7 | 3,5 | 1,5 |
| 4 0 | 38,6 | 2,9 | 1,4 |
| 2 0 | 13,35 | 2,1 | 1,0 |
| 1 0 | 12,25 | 1,7 | 0,85 |
| 0 8 | 10,125 | 1,333 &c. | 0,6 |
| 0 4 | 7,75 | 1,125 | 0,5 |
| 0 2 | 6,2 | 0,9 | 0,45 |
| 0 1 | 4,9 | 0,7 | 0,35 |
| 0 ½ | 3,9 | 0,55 | 0,25 |
| 6 drams | 3,5 | 0,5 | 0,225 |
| 4 drams | 2,2 | 0,3 | 0,2 |

The

The diameter of the nipple muſt always be equal to that of the former.

I have omitted the thickneſs of the moulds, it being very immaterial, provided they are ſubſtantial and ſtrong.

I would not adviſe thoſe who make rockets for private amuſement, to ram them ſolid, for it requires a very ſkillful hand, and an expenſive apparatus for boring them, which will be ſhewn hereafter. Driving of rockets ſolid is the moſt expeditious method, but not ſo certain as ramming them over a piercer, which I have found by experience.

## Moulds for Wheel Caſes or Serpents.

Fig. 12. repreſents a mould, in which the caſes are drove ſolid; L the nipple*, with a point† at top, which, when the caſe is filling, ſerves to ſtop the neck, and prevent the compoſition from falling out, which without this point it would do; and, in conſequence, the air would get into the vacancy in the charge, and at the time of firing cauſe the caſe to burſt. Theſe ſort of moulds are made of any length or diameter, according as the caſes are required; but the diameter of the rollers muſt be equal to half the bore, and the rammers made quite ſolid.

## To roll Rocket and other Caſes.

Sky-rocket caſes are to be made 6 ½ of their exterior diameter long, and all other caſes that are to be filled in moulds muſt be as long as the moulds, within half its interior diameter.

Rocket caſes, from the ſmalleſt to 4 or 6 pound, are generally made of the ſtrongeſt ſort of cartridge paper,

* The nipple and cylinder to bear the ſame proportion as thoſe for rockets.

† A round bit of br ſs, equal in length to the nick of the caſe, and flat at the top.

and

and rolled dry; but the large ſort are made of paſted paſte board. As it is very difficult to roll the ends of the caſes quite even, the beſt way will be to keep a pattern of the paper for the different ſorts of caſes, which pattern ſhould be ſomewhat longer than the caſe it is deſigned for, and on it marked the number of ſheets required, which will prevent any paper being cut to waſte: having cut your papers of a proper ſize, and the laſt ſheet for each caſe with a ſlope at one end, ſo that when the caſes are rolled it may form a ſpiral line round the outſide, and that this ſlope may always be the ſame, let the pattern be ſo cut for a guide: before you begin to roll, fold down one end of the firſt ſheet, ſo far that the fold will go 2 or 3 times round the former; then, on the double edge, lay the former with its handle off the table, and when you have rolled on the paper, within 2 or 3 turns, lay, on that part which is looſe, the next ſheet, and roll it all on.

Having thus done, you muſt have a ſmooth board, about 20 inches long, and equal in breadth to the length of the caſe; in the middle of this board muſt be a handle placed length-ways; under this board lay your caſe, and let one end of the board lie on the table; then preſs hard on it, and puſh it forwards, which will roll the paper very tight; do this 3 or 4 times before you roll on any more paper: this muſt be repeated every other ſheet of paper, till the caſe is thick enough; but if the rolling board be drawn backwards, it will looſen the paper: you are to obſerve, when you roll on the laſt ſheet, that the point of the ſlope be placed at the ſmall end of the roller. Having rolled your caſe to fit the mould, puſh in the ſmall end of the former F, about 1 diameter from the end of the caſe, and put in the end piece within a little diſtance of the former; then give the pinching cord one turn round the caſe, between the former and the end piece; at firſt pull eaſy, and keep moving the caſe, which will make the neck ſmooth, and without large wrinkles; when the caſes are hard to choak, let each ſheet of paper (except the firſt and laſt, in that part

part where the neck is formed) be a little moiſtened with water: immediately after you have ſtruck the concave ſtroke, bind the neck of the caſe round with ſmall twine, which muſt not be tied in a knot, but faſtened with 2 or 3 hitches.

Having thus pinched and tied the caſe ſo as not to give way, put it into the mould without its foot, and with a mallet drive the former hard on the end piece, which will force the neck cloſe and ſmooth; this done, cut the caſe to its proper length, allowing from the neck to the edge of the mouth half a diameter, which is = to the height of the nipple; then take out the former, and drive the caſe over the piercer with the long rammer, and the vent will be of a proper ſize. Wheel caſes muſt be drove on a nipple with a point, to cl ſe the neck, and make the vent of the ſize required; which, in moſt caſes, is generally ¼ of their interior diameter: as it is very oft difficult, when the caſes are rolled, to draw the roller out, you may make a hole through the handle, and put in it a ſmall iron pin, by which you may eaſily turn the former round, and pull it out. Fig. 17. ſhews the method of pinching caſes; P a treddle, which, when preſſed hard with the foot, will draw the cord tight, and force the neck as cloſe as you pleaſe; Q a ſmall wheel or pully, with a groove round it for the cord to run in.

Caſes are commonly rolled wet, for wheels and fixed pieces; and when they are required to contain a great length of charge, the method of making thoſe caſes is thus: Your paper muſt be cut as uſual, only the laſt ſheet muſt not be cut with a ſlope; having your paper ready, paſte each ſhe t on one ſide; then fold down the firſt ſheet as before directed, but be careful that the paſte does not touch the upper part of the fold, for if the roller be wetted, it will tear the paper in drawing it out: in paſting the laſt ſheet, obſerve not to wet the laſt turn or 2 in that part where it is to be pinched; for if that part be damp, the pinching cord will ſtick to it, and tear the paper; therefore, when you choak thoſe

caſes,

cafes, roll a bit of dry paper once round the cafe, before you put on the pinching cord; but this bit of paper muft be taken off after the cafe is choaked. The rolling board, and all other methods, according to the former directions for the rolling and pinching of cafes, muft be ufed to thefe as well as all other cafes.

## To make Tourbillon Cafes.

Thofe fort of cafes are generally made about 8 diameters long, but if very large, 7 will be fufficient: tourbillons will anfwer very well from 4 oz. to 2 lb. but when larger there is no certainty. The cafes are beft rolled wet with pafte, and the laft fheet muft have a ftrait edge, fo that the cafe may be all of a thicknefs: when you have rolled your cafes, after the manner of wheel cafes, pinch them at one end quite clofe; then, with the rammer, drive the ends down flat, and afterwards ram in about 1-3d of a diameter of dried clay. The diameter of the former for thefe cafes muft be the fame as for fky rockets.

N. B. Tourbillons are to be rammed in moulds without a nipple, or in a mould without its foot.

## Ballóón Cafes, or Paper Shells.

Firft you muft have an oval former turned of fmooth wood; then pafte a quantity of brown or cartridge paper, and let it lie till the pafte has quite foaked through; this done, rub the former with foap or greafe, to prevent the paper from fticking to it; then lay the paper on in fmall flips, till you have made it 1-3d of the thicknefs of the fhell intended; having thus done, fet it to dry, and when dry, cut it round the middle, and the 2 halves will eafily come off; but obferve, when you cut, to leave about 1 inch not cut, which will make the halves join much better than if quite feparated; when you have fome ready to join, place the halves even together, and pafte a flip of paper round the opening to hold them together,

together, and let that dry; then lay on paper all over as before, every where equal, excepting that end which goes downwards in the mortar, which may be a little thicker than the rest; for that part which receives the blow from the powder in the chamber of the mortar consequently requires the greatest strength: when the shell is thoroughly dry, burn a round vent at top, with square iron, large enough for the fuze: this method will do for ballóóns from 4 inches 2-5ths, to 8 inches diameter; but if they are larger, or required to be thrown a great height, let the first shell be turned of elm, instead of being made of paper.

For a ballóón of 4 inches 2-5ths, let the former be 3 inches 1-8th diameter, and 5 ½ inches long. For a ballóón of 5 ½ inches the diameter of the former must be 4 inches, and 8 inches long. For a ballóón of 8 inches, let the diameter of the former be 5 inches and 15-16ths, and 11 inches 7-8ths long. For a 10-inch ballóón, let the former be 7 inches 3-16ths diameter, and 14 ⅜ inches long. The thickness of a shell for a ballóón of 4 inches 2-5ths, must be ½ inch. For a ballóón of 5½ inches let the thickness of the paper be 5-8ths of an inch. For an 8-inch balloon, 7-8ths of an inch. And for a 10 inch ballóón, let the shell be 1 inch 1-8th thick.

Shells that are designed for stars only, may be made quite round, and the thinner they are at the opening, the better; for if they are too strong, the stars are apt to break at the bursting of the shell: when you are making the shell, make use of a pair of calibres, or a round gauge, so that you may not lay the paper thicker in one place than another; and also to know when the shell is of a proper thickness. Ballóóns must always be made to go easy into the mortars.

## Mixing Compositions.

The performance of the principal part of fireworks depends much on the compositions being well mixed; therefore

therefore great care muſt be taken in this part of the work, particularly for the compoſitions for ſky rockets. When you have 4 or 5 pounds of ingredients to mix, which is a ſufficient quantity at a time (for a larger proportion will not do ſo well) firſt put the different ingredients together; then work them about with your hands, till you think they are pretty well incorporated: after which put them into a lawn ſieve with a receiver and top to it; and if, after it is ſifted, any remains that will not paſs through the ſieve, grind it again till fine enough; and if it be twice ſifted, it will not be amiſs: but the compoſitions for wheels and common works are not ſo material, nor need not be ſo fine. But in all fixed works, from which the fire is to play regular, the ingredients muſt be very fine, and great care taken in mixing them well together; and obſerve that, in all compoſitions wherein are ſteel or iron filings, the hands muſt not touch; nor will any works, which have iron or ſteel in their charge, keep long in damp weather, without being properly prepared, according to the following directions.

## To preſerve Steel or Iron Filings.

It ſometimes may happen, that fireworks may be required to be kept a long time, or ſent abroad; neither of which could be done with brilliant fires, if made with filings unprepared; for this reaſon, that the ſaltpetre being of a damp nature, it cauſes the iron to ruſt, the conſequence of which is, that when the works are fired, there will appear but very few brilliant ſparks, but inſtead of them a number of red and droſſy ſparks; and beſides, the charge will be ſo much weakened, that if this was to happen to wheels, the fire will hardly be ſtrong enough to force them round: but to prevent ſuch accidents, prepare your filings thus. Melt in a glazed earthen pan ſome brimſtone over a ſlow fire, and when melted throw in ſome filings; which keep ſtirring about till they are covered with brimſtone: this you muſt do while

while it is on the fire; then take it off, and ſtir it very quick till cold, when you muſt roll it on a board with a wooden roller, till you have broke it as fine as corn powder; after which ſift from it as much of the brimſtone as you can. There is another method of preparing filings, ſo as to keep 2 or 3 months in winter; this may be done by rubbing them between the ſtrongeſt ſort of brown paper which before has been moiſtened with linſeed oil.

N. B. If the brimſtone ſhould take fire, you may put it out, by covering the pan cloſe at top: it is not of much ſignification what quantity of brimſtone you uſe, ſo that there is enough to give each grain of iron a coat; but as much as will cover the bottom of a pan of about 1 foot diameter, will do for 5 or 6 pound of filings, or caſt iron for gerbes.

## To drive or ram Sky Rockets, &c.

Rockets drove over a piercer muſt not have ſo much compoſition put in them at a time, as when drove ſolid, for the piercer, taking up great part of the bore of the caſe, would cauſe the rammer to riſe too high; ſo that the preſſure of it would not be ſo great on the compoſition, nor would it be drove every where equal: to prevent which, obſerve the following rule; that for thoſe rockets, that are rammed over a piercer, let the ladle* hold as much compoſition as, when drove, will raiſe the drift ½ the interior diameter of the caſe, and for thoſe drove ſolid to contain as much as will raiſe it ¾ the exterior diameter of the caſe: ladles are generally made to go eaſy in the caſe, and the length of the ſcoop about 1½ of its own diameter.

The charge of rockets muſt always be drove 1 diameter above the piercer, and on it muſt be rammed 1-3d of a diameter of clay, through the middle of which bore a ſmall hole to the compoſition, that, when the charge is burnt to the top, it may communicate its fire, through

* A copper ſcoop with a wooden handle.

the

the hole, to the ſtars in the head: great care muſt be taken to ſtrike with the mallet, and with an equal force, the ſame number of ſtrokes to each ladle-full of charge; otherwiſe the rockets will not riſe with an uniform motion, nor will the compoſition burn equal and regular; for which reaſon they cannot carry a proper tail, for it will break before the rocket has got half way up; inſtead of reaching from the ground to the top, where the rocket breaks and diſperſes the ſtars, rains, or whatever is contained in the head. When you are ramming, keep the drift conſtantly turning or moving; and when you uſe the hollow rammers, knock out of them the compoſition now and then, or the piercer will ſplit them: to a rocket of 4 oz. give to each ladle-full of charge 16 ſtrokes: to a rocket of 1 lb. 8: to a 2-pounder, 36: to a 4-pounder, 42: and to a 6-pounder, 56: but rockets of a larger ſort cannot be drove well by hand, but muſt be rammed with a machine made in the ſame manner as thoſe for driving piles, which are ſo very common to be ſeen, that I ſhall omit a deſcription.

The method of ramming of wheel caſes, or any other ſort, in which the charge is drove ſolid, is much the ſame as ſky rockets; for the ſame proportion may be obſerved in the ladle, and the ſame number of ſtrokes given, according to their diameters, all caſes being diſtinguiſhed by their diameters: in this manner, a caſe whoſe bore is equal to a rocket of 4 oz. is called a 4-oz. caſe, and that which is equal to an 8-oz. rocket an 8-oz. caſe, and ſo on, according to the different rockets.

Having taught the method of ramming caſes in moulds; we ſhall here ſay ſomething concerning thoſe filled without moulds; which method, for ſtrong paſted caſes, will do extremely well, and ſave the expence of making ſo many moulds. The reader muſt here obſerve, when he fills any ſort of caſes, to place the mould on a perpendicular block of wood, and not on any place that is hollow; for we have found by experience, that when caſes were rammed on driving benches, which were

formerly

formerly uſed, the works frequently miſcarried, on account of the hollow reſiſtance of the benches, which oft jarred and looſened the charge in the caſes; but this accident has never happened ſince the driving blocks* have been uſed.

When caſes are to be filled without moulds, proceed thus; have ſome nipples made of braſs or iron, of ſeveral ſorts and ſizes, in proportion to the caſes, and to ſcrew or fix in the top of the driving block; when you have fixed in a nipple, make, at about 1 ½ inch from it, a ſquare hole, in the block, 6 inches deep and 1 inch diameter; then have a piece of wood, 6 inches longer than the caſe intended to be filled, and 2 inches ſquare; on 1 ſide of it cut a groove almoſt the length of the caſe, whoſe breadth and depth muſt be ſufficient to cover near ½ the caſe; then cut the other end to fit the hole in the block, but take care to cut it ſo that the groove may be of a proper diſtance from the nipple: this half mould being made and fixed tight in the block, cut, in another piece of wood nearly of the ſame length as the caſe, a groove of the ſame dimenſions as that in the fixed piece; then put the caſe on the nipple, and with a cord tie it and the 2 half moulds together, and your caſe will be ready for filling.

The dimenſions of the above deſcribed half moulds, are proportionable for caſes of 8 ounces; but notice muſt be taken, that they differ in ſize in proportion to the caſes.

Note, the clay, mentioned in this article, muſt be prepared after this manner; get ſome clay, in which there is no ſtones nor ſand, and bake it in an oven till quite dry; then take it out and beat it to a powder, and afterwards ſift it through a common hair ſieve, and it will be fit for uſe.

* A piece of hard wood in the form of an anvil block.

Pro-

## Proportion of Mallets.

The best wood for mallets is dry beech. I would have every practitioner know, that if he uſes a mallet of a moderate ſize, in proportion to the rocket, according to his judgement, and if that rocket ſucceeds, he may depend on the reſt, by uſing the ſame mallet; yet it will be neceſſary that caſes of different ſorts be drove with mallets of different ſizes.

The following proportion of the mallets for rockets of any ſize, from 1 oz. to 6lb. may be obſerved; but as rockets are ſeldom made leſs than 1 oz. or larger than 6lb. I ſhall leave the management of them to the curious; but all caſes under 1 oz. may be rammed with an oz. rocket mallet. Your mallets will ſtrike more ſolid, by having their handles turned out of the ſame piece as the head, and made in a cylindrical form: let their dimenſions be worked by the diameters of the rockets: for example; let the thickneſs of the head be 3 diameters, and its length 4, and the length of the handle 5 diameters, whoſe thickneſs muſt be in proportion to the hand.

## Proportion of Sky Rockets, and Manner of heading them.

Fig. 13. a rocket compleat without its ſtick, whoſe length from the neck is 5 diameters 1-6th; the caſes ſhould always be cut to this length after they are filled: M the the head, which is 2 diameters high, and 1 diameter 1-6th ½ in breadth; N the cone or cap, whoſe perpendicular height muſt be 1 diameter 1 3-d. Fig. 14. the collar to which the head is fixed; this is turned out of deal or any light wood, and its exterior diameter muſt be equal to the interior diameter of the head; 1-6th will be ſufficient for its thickneſs, and round the outſide edge muſt be a groove; the interior diameter of the collar muſt not be quite ſo wide as the exterior diameter

of

of the rocket; when this is to be glued on the rocket, you muſt cut 2 or 3 rounds of paper off the caſe, which will make a ſhoulder for it to reſt upon. Fig. 15, a former for the head: 2 or 3 rounds of paper well paſted will be enough for the head, which, when rolled, put the collar on that part of the former marked O, which muſt fit the inſide of it; then, with the pinching cord pinch the bottom of the head into the groove, and tie it with ſmall twine. Fig. 16, a former for the cone. To make the caps, cut your paper in round pieces, equal in diameter to twice the length of the cone you intend to make; which pieces being cut into halves, will make 2 caps each, without waſting any paper; having formed the caps, paſte over each of them a thin wh te paper, which muſt be a little longer than the cone, ſo as to project about ½ an inch below the bottom: this projection of paper, being notched and paſted, ſerves to faſten the cap to the head.

When you load the heads of your rockets with ſtars, rains, ſerpents, crackers, ſcrolls, or any thing elſe, according to your fancy; remember always to put 1 ladle-full of meal powder into each head, which will be enough to burſt the head, and diſperſe the ſtars, or whatever it contains: when the heads are loaded with any ſort of caſes, let their mouths be placed downwards; and after the heads are filled, paſte on the top of them a piece of paper, before you put on the caps. As the ſize of ſtars oft differ, it would be needleſs to give an exact number for each rocket, but this rule may be obſerved, that the heads may be nearly filled with whatever they are loaded.

## Decorations for Sky Rockets.

Sky rockets bearing the pre-eminence of all fireworks, it will not be improper to treat of their various kinds of decorations, which are directed according to fancy; ſome are headed with ſtars of different ſorts, ſuch as tailed, brilliant, white, blue and yellow ſtars, &c. ſome with gold and ſilver rain; others with ſerpents, crackers, fire-

ſcrolls, marrons; and ſome with ſmall rockets, and many other devices, as the maker pleaſes.

## Dimenſions and Poiſe of Rocket Sticks.

| Weight of the rocket. | | Length of the ſtick. | | Thickneſs at top. | Breadth at top. | Square at bottom. | Poiſe from the point of the cone. | |
|---|---|---|---|---|---|---|---|---|
| lb. | oz. | ft. | in. | Inches. | Inches | Inches | ft. | in. |
| 6 | 0 | 14 | 0 | 1,5 | 1,85 | 0,75 | 4 | 1,5 |
| 4 | 0 | 12 | 10 | 1,25 | 1,40 | 0,625 | 3 | 9, |
| 2 | 0 | 9 | 4 | 1,125 | 1, | 0,525 | 2 | 9, |
| 1 | 0 | 8 | 2 | 0,725 | 0,80 | 0,375 | 2 | 1, |
| | 8 | 6 | 6 | 0,5 | 0,70 | 0,25 | 1 | 10,5 |
| | 4 | 5 | 3 | 0,3750 | 0,55 | 0,35 | 1 | 8,5 |
| | 2 | 4 | 1 | 0,3 | 0,45 | 0,15 | 1 | 3, |
| | 1 | 3 | 6 | 0,25 | 0,35 | 0,10 | 11 | 0, |
| | ½ | 2 | 4 | 0,125 | 0,20 | 0,16 | 8 | 0, |
| | ¼ | 1 | 10½ | 0,1 | 0,15 | 0,5 | 5 | 0,5 |

The laſt column on the right, in the above table, expreſſes the diſtance from the top of the cone, where the ſtick, when tied on, ſhould balance the rocket, ſo as to ſtand in an equilibrium on one's finger, or the edge of a knife. The beſt wood for the ſticks is dry deal, made thus; when you have cut and planed the ſticks according to the dimenſions given in the table, cut on 1 of the flat ſides at top, a groove the length of the rocket, and as broad as the ſtick will allow; then on the oppoſite flat ſide, cut 2 notches for the cord, which ties on the rocket, to lay in; 1 of theſe notches muſt be near the top of the ſtick, and the other facing the neck of the rockets; the diſtance between theſe notches may eaſily be known, for the top of the ſtick ſhould always touch the head of the rocket. When your rockets and ſticks are ready, lay the rockets in the grooves in the ſticks, and

and tie them on. Thoſe who, merely for curioſity, may chuſe to make rockets of different ſizes, to what I have expreſſed in the table of dimenſions, may find the length of their ſticks, by making them for rockets, from ½ oz. to 1 lb. 60 diameters of the rocket long; and for rockets above 1 lb. 50 or 52 diameters will be a good length; their thickneſs at top may be about ½ a diameter, and their breadth a very little more; their ſquare at bottom is generally equal to ½ the thickneſs at top. But, although the dimenſions of the ſticks be very nicely obſerved, you muſt depend only on their balance: for, without a proper counterpoiſe, your rockets, inſtead of mounting perpendicularly, will take an oblique direction, and fall to the ground before they are burnt out.

## Boring Rockets which have been drove ſolid.

Plate 2, Fig. 18, repreſents the plan of an apparatus, or lathe, for boring of rockets; A the large wheel which turns the ſmall one B, that works the reammer C: theſe reammers are of different ſizes according to the rockets; they muſt be of the ſame diameter as the top of the bore intended, and continue that thickneſs a little longer than the depth of the bore required, and their points muſt be like that of an auger; the thick end of each reammer muſt be made ſquare, and all of the ſame ſize, ſo as to fit into one ſocket, wherein they are faſtened by a ſcrew D; E the guide for the reammer, which is made to move backwards and forwards; ſo that, after you have marked the reammer 3 ½ diameters of the rocket from the point, ſet the guide, allowing for the thickneſs of the fronts of the rocket boxes, and the neck and mouth of the rocket, ſo that when the front of the large box is cloſe to the guide, the reammer may not go too far up the charge. F, boxes for holding the rockets, which are made ſo as to fit one in another; their ſides muſt be equal in thickneſs to the difference of the diameters of the rockets, and their interior diameters equal to the exterior diameters of the rockets. To prevent the rockets turning round while

boring, a piece of wood muſt be placed againſt the end of the box in the inſide, and preſſed againſt the tail of the rocket; this will alſo hinder the reammer from forcing the rocket backwards. G, a rocket in the box. H, a box that ſlides under the rocket boxes to receive the borings from the rockets, which fall through holes made on purpoſe in the boxes; theſe holes muſt be juſt under the mouth of the rocket, one in each box, and all to correſpond with each other.

Fig. 19, is a front view of the large rocket box. I, an iron plate, in which are holes of different ſizes, through which the reammer paſſes; this plate is faſtened with a ſcrew in the centre, ſo that when you change the reammer, you turn the plate round, but always let the hole you are going to uſe be at the botom: the fronts of the other boxes muſt have holes in them to correſpond with them in the plate. K, the lower part of the large box, which is made to fit the inſide of the lathe, that all the boxes may move quite ſteady.

Fig. 20, is a perſpective view of the lathe. L, the guide for the reammer, which is ſet by the ſcrew at bottom.

Fig. 21, a view of the front of the guide facing the reammer. M, an iron plate, of the ſame dimenſions as that on the front of the box, and placed in the ſame direction, and alſo to turn on a ſcrew in the centre. N, the rocket box, which ſlides backwards and forwards: when you have fixed a rocket in the box, puſh it forwards againſt the reammer; and when you think the ſcoop of the reammer is full, draw the box back, and knock out the compoſition; this you muſt do till the rocket is bored, or it will be in danger of taking fire; and if you bore in a hurry, wet the end of the reammer now and then with oil to keep it cool.

Having bored a number of rockets, you muſt have taps of different ſorts according to the rockets. Theſe taps are a little longer than the bore, but when you uſe them mark them $3\frac{1}{2}$ diameters from the point, allowing for the thickneſs of the rocket's neck; then, holding the

the rocket in one hand, you tap it with the other. To explain theſe taps, I have repreſented 1 by Fig. 22. They are made in the ſame proportion as the fixed piercers, and are hollowed their whole length.

## Hand Machine uſed for boring of Rockets inſtead of a Lathe.

Theſe ſort of machines anſwer very well, but not ſo expeditious as the lathe, nor are they ſo expenſive to make; they may be worked by 1 man; but the lathe will require 3. Fig. 23, repreſents the machine. O, the rocket boxes, which are to be fixed, and not to ſlide as thoſe in the lathe. P Q, are guides for the reammers, that are made to ſlide together, as the reammer moves forward: the reammers for theſe ſort of machines muſt be made of a proper length, allowing for the thickneſs of the front of the boxes, and the length of the mouth and neck of the caſe: on the ſquare end of theſe reammers, muſt be a round ſhoulder of iron, to turn againſt the outſide of the guide Q, by which means the guides are forced forwards. R, the ſtock which turns the reammer, and while turning muſt be preſſed towards the the rocket, by the body of the man who works it; all the reammers are to be made to fit 1 ſtock. This machine as well as the lathe is made by the ſcale in the ſame place.

## To make large Gerbes.

Fig. 24, repreſents a wooden former; 25, a gerbe complete, with its foot or ſtand. The caſes for gerbes are made very ſtrong, on account of the ſtrength of the compoſition; which, when fired, comes out with great velocity; therefore, to prevent their burſting, the paper ſhould be paſted, and the caſes made as thick at the top as at the bottom; they ſhould alſo have very long necks, for this reaſon; firſt, that the particles of iron will have more time to be heated, by meeting with greater reſiſt-

in getting out, than with a ſhort neck, which would be burnt too wide before the charge be conſumed, and ſpoil the effect: Secondly, that with long necks the ſtars will be thrown to a great height, and will not fall before they are ſpent, or ſpread too much; but, when made to perfection will riſe and ſpread in ſuch a manner as to form exactly a wheat-ſheaf.

In the ramming of gerbes, there will be no need of a mould, the caſes being ſufficiently ſtrong to ſupport themſelves; but you are to be careful, before you begin to ram, to have a piece of wood made to fit in the neck; for if this be not done, the compoſition will fall into the nec , and leave a vacancy in the caſe, which, as I ſaid before, will cauſe the caſe to burſt ſo ſoon as the fire arrives at the vacancy: you muſt likewiſe obſerve, that the firſt ladle of charge, or 2, if you think proper, be of ſome weak compoſition. When the caſe is filled, take out the piece of wood, and fill the neck with ſome ſlow charge. Gerbes are generally made about ſix diameters long, from the bottom to the top of the neck; their bore muſt be 1-5th narrower at top than at bottom. The neck S is 1-6th diameter and $\frac{3}{4}$ long. T, a wooden foot or ſtand, on which the gerbe is fixed. This may be made with a choak or cylinder, 4 or 5 inches long, to fit the inſide of the caſe, or with a hole in it to put in the gerbe; both theſe methods will anſwer the ſame. Gerbes produce a moſt brilliant fire, and are very beautiful when a number of them are fixed in the front of a building, or a collection of fireworks.

N. B. Gerbes are made by their diameters, and their caſes at bottom $\frac{1}{4}$ thick. The method of finding the interior diameter of a gerbe is thus: Suppoſing you would have the exterior diameter of the caſe, when made, to be 5 inches, then, by taking 2-4ths for the ſides of the caſe, there will remain 2 $\frac{1}{2}$ inches for the bore, which will be a very good ſize. Theſe ſort of gerbes ſhould be rammed very hard.

Small

## Small Gerbes, or White Fountains,

May be made of 4, 8 oz. or 1 lb. cafes, pafted and made very ftrong, of what length you pleafe; but, before you fill them, drive in dry clay 1 diameter of their orifice high; and, when you have filled a cafe, bore a vent through the centre of the clay to the compofition; the common proportion will do for the vent, which muft be primed with a flow charge. Thefe fort of cafes, without the clay, may be filled with Chinefe fire.

## To make Pafte-board and Paper Mortars.

Fig. 26, a former, and 27, an elm foot for the mortar; 28, a mortar complete; thefe mortars are beft when made with pafteboard, well pafted before you begin; or, inftead of pafte, you may ufe glue. For a coehorn mortar, which is 4 inches 2-5ths diameter, roll the pafteboard on the former 1-6th of its diameter thick; and, when dry, cut one end fmooth and even; then nail and glue it on the upper part of the foot; when done, cut off the pafte-board at top, allowing for the length of the mortar 2 ½ diameters from the mouth of the powder chamber; then bind the mortar round with a ftrong cord wetted with glue. U, the bottom part of the foot, is 1 diameter 2-3ds broad, and 1 diameter high; and that part which goes into the mortar is 2-3ds of its diameter high. W, is a copper chamber for powder, made in a conical form, and is 1-3d of the diameter wide, 1 ½ of its own diameter long; in the centre of the bottom of this chamber, make a fmall hole a little way down the foot; this hole muft be met by another of the fame fize, made in the fide of the foot, as is fhewn in Fig. 28. If thefe holes are made true, and a copper pipe fitted into both, the mortar when loaded will prime itfelf, for the powder will naturally fall to the bottom of the firft hole; then by putting a bit of quick-match in the fide hole, your mortar will be ready to be fired.

Mortars of $5\frac{1}{2}$, 8, and 10 inches diameter, may be made of paper, or paſte-board, by the above method, and in the ſame proportion; but if larger, it will be beſt to have them made of braſs. N. B. The copper chamber muſt have a ſmall rim round its edge with holes in it, for ſcrews to make it faſt in the foot.

## SECT. IV.—To load Air Ballóóns, with the Number of Stars, Serpents, Snakes, Rain-falls, &c. in Shells of each Nature.

BALLOONS being in great eſteem, by admirers of fire works, I ſhall give a full deſcription of them.

When you fill your ſhells, you muſt firſt put in the ſerpents, rains, ſtars, &c. or whatever they are compoſed of; then the blowing powder; but the ſhells muſt not be quite filled; all thoſe things muſt be put in at the fuze hole; but marrons, being too large to go in at the fuze hole, muſt be put in before the inſide ſhell be joined. When the ſhells are loaded, glue and drive in the fuzes very tight. Of theſe fuzes we ſhall ſay more hereafter; but ſhall here give the diameter of the fuze hole in ballóóns of each nature, which are,—For a coehorn ballóón, let the diameter of the fuze hole be 7-8ths of an inch. For a royal ballóón, which is near $5\frac{1}{2}$ inches diameter, make the fuze hole 1 inch 1-8th diameter. For an 8-inch ballóón, 1 inch 3-8ths: and for a 10-inch ballóón, 1 inch 5-8ths.

Having proceeded thus far with the directions of loading ballóóns, I ſhall in the ſecond place give an account of the quantities and number of each article proper for ſhells of each nature; but it is to be obſerved, that air-ballóóns are divided into 4 ſorts, viz. firſt, illuminated ballóóns; ſecond, ballóóns of ſerpents; third, ballóóns of

of reports, marrons, and crackers; and fourth, compound ballóóns.

## Coehorn Ballóón illuminated.

| | | oz. |
|---|---|---|
| Meal powder | — — — | 1½ |
| Corn powder | — — — | 0½ |
| Powder for the mortar | — — | 2 |

Length of the fuze compoſition ¾ of an inch; 1 oz. drove or rolled ſtars, as many as will nearly fill the ſhell.

## Coehorn Ballóón of Serpents.

| | | oz. |
|---|---|---|
| Meal powder | — — — | 1¼ |
| Corn powder | — — | 1 |
| Powder for the mortar | — — | 2¼ |

Length of the fuze compoſition 13 16ths of an inch. ½ oz. caſes drove 3 diameters and bounced 3 diameters; and ½ oz. caſes drove 2 diameters and bounced 4; of each an equal quantity, and as many of them as will fit in eaſily, placed head to tail.

## Coehorn Ballóón of Crackers and Reports.

| | | oz. |
|---|---|---|
| Meal powder | — — | 1¼ |
| Corn powder | — — | 0¾ |
| Powder for the mortar | — | 2 |

Length of the fuze compoſition ¾ of an inch. Reports 4, and crackers of 6 bounces, as many as will fill the ſhell.

Compound

## Compound Coehorn Ballóóns.

| | | oz. | dr. |
|---|---|---|---|
| Meal } powder { | — — | 1 | 4 |
| Corn } powder { | — — | 0 | 12 |
| Powder for the mortar | — — | 2 | 4 |

Length of the fuze compoſition 13 16ths of an inch. ½ oz. caſes drove 3 ½ diameters and bounced 2, fixteen; ½ oz. caſes drove 4 diameters and not bounced, 10. Blue ſtrung ſtars, 10. Rolled ſtars as many as will complete the ballóón.

## Royal Ballóóns illuminated.

| | | oz. | dr. |
|---|---|---|---|
| Meal } powder { | — — | 1 | 8 |
| Corn } powder { | — — | 0 | 12 |
| Powder for the mortar | — | 3 | 0 |

Length of the fuze compoſition 15 16ths of an inch. 2 oz. ſtrung ſtars, 54: Rolled ſtars as many as the ſhell will contain, allowing room for the fuze.

## Royal Ballóóns of Serpents.

| | | oz. | dr. |
|---|---|---|---|
| Meal } powder { | — — | 1 | 0 |
| Corn } powder { | — — | 1 | 8 |
| Powder for the mortar | — | 3 | 8 |

Length of the fuze compoſition 1 inch. 1 oz. caſes drove 3 ½ and 4 diameters, and bounced 2, of each an equal quantity, ſufficient to load the ſhell.

Royal

## Royal Ballóóns with Crackers and Marrons.

| | oz. | dr. |
|---|---|---|
| Meal powder | 1 | 8 |
| Corn powder | 1 | 4 |
| Powder for firing the mortar | 3 | 0 |

Length of the fuze compoſition 14 16ths of an inch; reports 12, and completed with crackers of 8 bounces.

## Compound Royal Ballóóns.

| | oz. | dr. |
|---|---|---|
| Meal Powder | 1 | 5 |
| Corn Powder | 1 | 6 |
| Powder for the mortar | 3 | 12 |

Length of the fuze compoſition 1 inch. ½ oz. caſes drove and bounced 2 diameters, 8. 2 ounce caſes filled 3-8ths of an inch with ſtar compoſition, and bounced 2 diameters, 8. Silver rain-falls, 10. 2 oz. tailed ſtars, 16. Rolled brilliant ſtars, 30. If this ſhould not be ſufficient to load the ſhell, you may complete it with gold rain-falls.

## Eight-inch Ballóóns illuminated.

| | oz. | dr. |
|---|---|---|
| Meal powder | 2 | 8 |
| Corn powder | 1 | 4 |
| Powder for the mortar | 9 | 0 |

Length of the fuze compoſition 1 inch 1 8th. 2 oz. drove ſtars, 48. 4 oz. caſes drove with ſtar compoſition 3 8ths of an inch, and bounced 3 diameters, 12; and the ballóón completed with 2 oz. drove brilliant ſtars.

Eight

## Eight-inch Ballóóns of Serpents.

| | oz. | dr. |
|---|---|---|
| Meal } powder | 2 | 0 |
| Corn } powder | 2 | 0 |
| Powder for the mortar | 9 | 8 |

Length of the fuze compofition 1 inch 3 16ths. 2 oz. cafes drove 1 ½ diameter, and bounced 2; and 1 oz. cafes drove 2 diameters, and bounced 2 ½; of each an equal quantity, fufficient for the fhell.

N. B. The ftar compofition drove in bounced cafes, muft be managed thus; firft, the cafes muft be pinched clofe at 1 end, then the corn powder put in for a report, and the cafe pinched again clofe to the powder, only leaving a fmall vent for the ftar compofition, which is drove at top, to communicate to the powder at the bounce end.

### R E M A R K S.

Ballóóns filled with crackers, reports, and marrons, make no great fhow of themfelves, nor are they very pleafing to the eye, for they reprefent nothing more than a number of pale white flafhes, followed by a variety of reports; which all together make but a very indifferent appearance, when fired with illuminated ballóóns, which are fo beautiful and brilliant, as to give fuch luftre as will dazzle the eyes of the fpectators for fome time. On this confideration, I do not think it worth while loading fhells of a large nature with things that afford fo little pleafure; but they have a pretty good effect in royal fhells, when thrown among a number of air works, fuch as pots des brins or flights of rockets, in order to alarm the people with a thundering in the air. For they will not know from whence the reports came, if fired exactly at the fame time with the other works, and the fuze made to carry a fmall fire. But if any one thinks proper to make

make large ballóóns of this fort, it is only obferving a proportion of the blowing and firing powder, and the length of the fuze, for fhells of the fame dimenfions as thofe you intend to make. Thefe kind of ballóóns are lighter than any other, by reafon of the crackers being light, and not lying clofe in the fhells. It muft be obferved, when you fire light ballóóns, not to put fo much powder in the mortar as for heavy.

## Compound 8-inch Ballóóns.

| | oz. | dr. |
|---|---|---|
| Meal } powder | 2 | 8 |
| Corn } powder | 1 | 12 |
| Powder for the mortar | 9 | 4 |

Length of the fuze compofition 1-8th. 4 oz. cafes drove with ftar compofition 3-8ths of an inch, and bounced 3 diameters, 16. 2 oz. tailed ftars, 16. 2 oz. drove brilliant ftars, 12. Silver rain-falls, 20. 1 oz. drove blue ftars, 20: and 1 oz. cafes drove and bounced 2 diameters, as many as will fill the fhell.

## Another of 8 inches.

| | oz. | dr. |
|---|---|---|
| Meal } powder | 2 | 8 |
| Corn } powder | 1 | 12 |
| Powder for the mortar | 9 | 4 |

Length of the fuze compofition 1 inch 1 8th; crackers of 6 reports, 10. Gold rains, 14. 2 oz. cafes drove with ftar compofition 3 8ths of an inch, and bounced 2 diameters, 16. 2 oz. tailed ftars, 16. 2 oz. drove brilliant ftars, 12. Silver rains, 10. 1 oz. drove blue ftars, 20: and 1 oz. cafes drove with a brilliant charge 2 diameters and bounced 3, as many as the fhell will hold.

Another

## Another of 8 inches.

| | oz. | dr. |
|---|---|---|
| Meal powder | 2 | 12 |
| Corn powder | 2 | 0 |
| Powder for the mortar | 9 | 0 |

Length of the fuze compoſition 1 inch 1 16th. Crackers of 6 reports, 10. Gold rains, 20. 2 oz. caſes drove with ſtar compoſition ½ an inch, and bounced 2 diameters, 16. 2 oz. drove brilliant ſtars, 2 oz. drove blue ſtars, 2 oz. drove coloured ſtars, 2 oz drove tailed ſtars, large ſtrung ſtars, and rolled ſtars, of each an equal quantity, ſufficient for the ballóón.

## A compound 10-inch Ballóón.

| | oz. | dr. |
|---|---|---|
| Meal powder | 3 | 4 |
| Corn powder | 2 | 8 |
| Powder for the mortar | 12 | 8 |

Length of the fuze compoſition 15 16ths of an inch. 1 oz. caſes drove and bounced 3 diameters, 16. Crackers of 8 reports, 12. 4 oz. caſes drove ½ an inch with ſtar compoſition, and bounced 2 diameters, 14. 2 oz. caſes drove with brilliant fire 1 ¼ diameter, and bounced 2 diameters, 16. 2 oz. drove brilliant ſtars, 30. 2 oz. drove blue ſtars, 30. Gold rains, 20. Silver rains 20. After all theſe are put in, fill the remainder of the caſe with tailed and rolled ſtars.

## Ten-inch Ballóón of 3 changes.

| | oz. | dr. |
|---|---|---|
| Meal powder | 3 | 0 |
| Corn powder | 3 | 2 |
| Powder for the mortar | 13 | 0 |

Length

Length of the fuze compofition 1 inch. The fhell muft be loaded with 2 oz. cafes, drove with ftar compofition ¼ of an inch, and on that 1 diameter of gold fire, then bounced 3 diameters; or with 2 oz. cafes firft filled 1 diameter with gold-fire, then ¼ of an inch with ftar compofition, and on that 1 diameter and ¼ of brilliant fire. Thefe cafes muft be well fecured at top of the charge, left they fhould take fire at both ends; but their necks muft be larger than the common proportion.

## To make Ballóón Fuzes.

Fuzes for air ballóóns are fometimes turned out of dry beech, with a cup at top, to hold the quick-match, as you fee in Plate II. Fig. 28, but if made with pafted paper, they will do as well: the diameter of the former for fuzes for coehorn ballóóns, muft be ½ an inch; for a royal fuze, 5 8ths of an inch; for an 8-inch fuze, ¾ of an inch; and for a 10-inch fuze, 7 8ths of an inch. Having rolled your cafes, pinch and tie them almoft clofe at one end; then drive them down, and let them dry; before you begin to fill them, mark, on the outfide of the cafe, the length of charge required, allowing for the thicknefs of the bottom; and when you have rammed in the compofition, take 2 pieces of quick-match, about 6 inches long, and lay one end of each on the charge, and then a little meal powder, which ram down hard; the loofe ends of the match double up into the top of the fuze, and cover it with a paper cap to keep it dry. When you put the fhells in the mortars, uncap the fuzes, and pull out the loofe ends of the match, and let them hang on the fides of the ballóóns. The ufe of the match is, to receive the fire from the powder in the chamber of the mortar, in order to light the fuze: the fhell being put in the mortar with the fuze uppermoft, and exactly in the centre; fprinkle over it a little meal-powder, and it will be ready to be fired. Fuzes made of wood muft be longer than thofe of paper, and not bored quite through, but left folid about ½ an inch at bottom; and

when

when you uſe them, ſaw them off to a proper length, meaſuring the charge from the cup at top.

## Tourbillons.

Having filled ſome caſes within about 1 ¼ diameter, drive in a ladle-full of clay, then pinch their ends cloſe, and drive them down with a mallet; when done, find the centre of gravity of each caſe, where you nail and tie a ſtick, which ſhould be ½ an inch broad at the middle, and run a little narrower to the ends: theſe ſticks muſt have their ends turned upwards, ſo that the caſes may turn horizontally on their centres: at the oppoſite ſides of the caſes, at each end, bore a hole cloſe to the clay with a gimblet, the ſize of the neck of a common caſe of the ſame nature; from theſe holes draw a line round the caſe, and at the under part of the caſe bore a hole, with the ſame gimblet, within ½ a diameter of each line towards the centre, then from one hole to the other draw a right line. This line divide into 3 equal parts, and at X and Y, Fig. 29, Plate III. bore a hole, then from theſe holes to the other 2, lead a quick-match, over which paſte a thin paper. Fig. 30 repreſents a tourbillon as it ſhould lie to be fired, with a leader from one ſide hole A, to the other B. When you fire tourbillons, lay them on a ſmooth table, with their ſticks downwards, and burn the leader through the middle with a port fire. They ſhould ſpin 3 or 4 ſeconds on the table before they riſe, which is about the time the compoſition will be burning, from the ſide holes to thoſe at bottom.

To tourbillons may be fixed reports, in this manner: in the centre of the caſe at top, make a ſmall hole, and in the middle of the report make another; then place them together, and tie on the report, and with a ſingle paper ſecure it from fire: this done, your tourbillon is compleated. By this method you may fix on tourbillons, ſmall cones of ſtars, rains, &c. but be careful not to load them too much. 1 8th of an inch will be enough for the thickneſs of the ſticks, and their length equal to that of the caſes.

To

## To make Mortars to throw Aigrettes, and to load and fire them.

Mortars to throw aigrettes are generally made of paste-board, of the same thickness as balloon mortars, and 2 ½ diameters long in the inside from the top of the foot: the foot must be made of elm without a chamber, but flat at top, and in the same proportion as those for balloon mortars; these mortars must also be bound round with cord as before mentioned: sometimes 8 or 9 of these mortars, of about 3 or 4 inches diameter, are bound all together so as to appear but 1; but when they are made for this purpose, the bottom of the foot must be of the same diameter as the mortars, and only ½ a diameter high. Your mortars being bound well together, fix them on a heavy solid block of wood: to load these mortars, first put on the inside bottom of each, a piece of paper, and on it spread 1 ½ oz. of meal and corn powder mixed; then tie your serpents up in parcels with quick-match, and put them in the mortar with their mouths downwards; but take care the parcels do not fit too tight in the mortars, and that all the serpents have been well primed with powder wetted with spirit of wine: on the top of the serpents in each mortar lay some paper or tow; then carry a leader from one mortar to the other all round, and then from all the outside mortars into that in the middle: these leaders must be put between the cases and the sides of the mortar, down to the powder at bottom: in the centre of the middle mortar fix a fire-pump, or brilliant fountain, which must be open at bottom, and long enough to project out of the mouth of the mortar; then paste paper on the tops of all the mortars.

Mortars thus prepared are called a Nest of Serpents, as represented by Fig. 31. When you would fire these mortars, light the fire-pump C, which when consumed will communicate to all the mortars at once, by means of the leaders. For mortars of 6, 8, or 10 inches dia-

meter, the ſerpents ſhould be made in 1 and 2 oz. caſes, 6 or 7 inches long, and fired by a leader, brought out of the mouth of the mortar, and turned down the outſide, and the end of it covered with paper, to prevent the ſparks of the other works from ſetting it on fire. For a 6 inch mortar, let the quantity of powder for firing be 2 oz. for an 8-inch, 2 ¾ oz. and for a 10 inch, 3 ¾ oz. Care muſt be taken in theſe, as well as ſmall mortars, not to put the ſerpents in too tight, for fear of burſting the mortars. Theſe mortars may be loaded with ſtars, crackers, &c.

If the mortars, when loaded, are to be ſent any diſtance, or liable to be much moved, the firing powder ſhould be ſecured from getting amongſt the ſerpents, which would endanger the mortars, as well as hurt their performance; to prevent which, load your mortars thus: firſt put in the firing powder, and ſpread it equally about; then cut a round piece of blue touch-paper, equal to the exterior diameter of the mortar, and draw on it a circle, equal to the interior diameter of the mortar, and notch it all round as far as that circle; then paſte that part which is notched, and put it down the mortar cloſe to the powder, and ſtick the paſted edge to the mortar: this will keep the powder always ſmooth at bottom, ſo that it may be moved or carried any where, without receiving damage. The large ſingle mortars are called Pots des Aigrettes.

## Making, loading, and firing of Pots des Brins.

Theſe are made of paſte-board, and muſt be rolled pretty thick; uſually made 3 or 4 inches diameter, and 4 diameters long, and pinched with a neck at one end, like common caſes. A number of theſe are placed on a plank thus: having fixed on a plank 2 rows of wooden pegs, cut, in the bottom of the plank, a groove the whole length under each row of pegs; then, through the centre of each peg, bore a hole down to the groove

a

at bottom, and on every peg fix and glue a pot, whofe mouth muft fit tight on the peg: through all the holes run a quick-match, one end of which muft go into the pot, and the other into the groove, which muft have a match laid in it from end to end, and covered with paper, fo that when lighted at one end, it may difcharge the whole almoft inftantaneoufly: in all the pots put about 1 oz. of meal and corn powder; then in fome put ftars, and others rains, fnakes, ferpents, crackers, &c. when they are all loaded, pafte paper over their mouths. 2 or 300 of thefe pots being fired together, make a very pretty fhow, by affording fo great a variety of fires. Fig. 32 is a range of pots des brins, with the leader A, by which they are fired.

## Pots des Sauciffons

Are generally fired out of large mortars without chambers, the fame as thofe for aigrettes, only fomewhat ftronger: fauciffons are made of 1 and 2 oz. cafes, 5 or 6 inches long, and choaked in the fame maner as ferpents: half the number which the mortar contains, muft be drove 1 ½ diameter with compofition, and the other half 2 diameters, fo that when fired they may give 2 volleys of reports; but if the mortars are very ftrong, and will bear a fufficient charge, to throw the fauciffons very high, you may make 3 volleys of reports, by dividing the number of cafes into 3 parts, and making a difference in the height of the charge: after they are filled, pinch and tie them at top of the charge, almoft clofe; only leaving a fmall vent to communicate the fire to the upper part of the cafe, which muft be filled with corn powder very near the top; then pinch the end quite clofe, and tie it; after this is done, bind the cafe very tight with waxed pack-thread, from the choak at top of the compofition, to the end of the cafe; this will make the cafe very ftrong in that part, and caufe the report to be very loud: fauciffons fhould be rolled a little thicker of paper than the common proportion. When they are to be put in the mortar, they muft be primed in their

mouths, and fired by a caſe of brilliant fire fixed in their centre.

The charge for theſe mortars ſhould be 1-6th, or 1-8th, more than for pots des aigrettes of the ſame diameter.

## To fix one Rocket on the Top of another.

When ſky rockets are thus managed, they are called Towering Rockets, on account of their mounting ſo very high. Towering rockets are made after this manner; fix on a pound rocket a head without a collar; then take a 4 oz. rocket, which may be headed or bounced, and rub the mouth of it with meal powder wetted with ſpirit of wine; when done, put it in the head of the large rocket with its mouth downwards; but before you put it in, ſtick a bit of quick-match in the hole in the clay of the pound rocket, which match ſhould be long enough to go a little way up the bore of the ſmall rocket, to fire it, when the large is burnt out: the 4 oz. rocket being too ſmall to fill the head of the other, roll round it as much tow as will make it ſtand upright in the centre of the head: the rocket being thus fixed, paſte a ſingle paper round the opening of the top of the head of the large rocket. The large rocket muſt have only half a diameter of charge rammed above the piercer, for, if filled to the uſual height, it would turn before the ſmall one takes fire, and entirely deſtroy the intended effect: when one rocket is headed with another, there will be no occaſion for any blowing powder; for the force with which it ſets off, will be ſufficient to diſengage it from the head of the firſt fired rocket. The ſticks for theſe rockets muſt be a little longer than for thoſe headed with ſtars, rains, &c.

## Caduceus Rockets,

In riſing, form 2 ſpiral lines, or double worm, by reaſon of their being placed obliquely, one oppoſite the

other;

other; and their counterpoiſe in their centre, which cauſes them to riſe in a vertical direction. Rockets for this purpoſe muſt have their ends choaked cloſe, without either head or bounce; for a weight at top would be a great obſtruction to their mounting; though I have known them ſometimes to be bounced, but then they did not riſe ſo high as thoſe that were not; nor do any Caduceus rockets aſcend ſo high as ſingle, becauſe of their ſerpentine motion, and likewiſe the reſiſtance of air, which is much greater than 2 rockets of the ſame ſize would meet with, if fired ſingly.

By Fig. 33. you ſee the method of fixing theſe rockets: the ſticks for this purpoſe muſt have all their ſides equal, which ſides ſhould be equal to the breadth of a ſtick proper for a ſky rocket of the ſame weight as thoſe you intend to uſe, and to taper downwards as uſual, long enough to balance them, 1 length of a rocket, from the croſs ſtick; which muſt be placed from the large ſtick, 6 diameters of 1 of the rockets, and its length 7 diameters; ſo that each rocket, when tied on, may form with the large ſtick an angle of 60 degrees. In tying on the rockets, place their heads on the oppoſite ſides of the croſs ſtick, and their ends on the oppoſite ſides of the long ſtick; then carry a leader from the mouth of one into that of the other. When theſe rockets are to be fired, ſuſpend them between 2 hooks or nails, then burn the leader through the middle, and both will take fire at the ſame time. Rockets of 1 lb. are a good ſize for this uſe.

## Honorary Rockets

Are the ſame as ſky rockets, except that they carry no head nor report, but are cloſed at top, on which is fixed a cone; then on the caſe, cloſe to the top of the ſtick, you tie a 2 oz. caſe, about 5 or 6 inches long, filled with a ſtrong charge, and pinched cloſe at both ends; then in the reverſe ſides, at each end, bore a hole in the ſame manner as in tourbillons; from each hole carry a

leader into the top of the rocket. When the rocket is fired, and arrived to its proper height, it will give fire to the caſe at top, which will cauſe both rocket and ſtick to ſpin very faſt in their return, and repreſent a worm of fire, deſcending to the ground.

There is another method of placing the ſmall caſe, which is by letting the ſtick riſe a little above the top of the rocket, and tying the caſe to it, ſo as to reſt on the rocket: theſe rockets have no cones.

There is alſo a third method, by which they are managed, which is thus: in the top of a rocket fix a piece of wood, in which drive a ſmall iron ſpindle; then make a hole in the middle of the ſmall caſe, through which put the ſpindle; then fix on the top of it a nut, to keep the caſe from falling off; when this is done, the caſe will turn very faſt, without the rocket: but this method does not anſwer ſo well as either of the former.

Fig. 34. is the honorary rocket complete. The beſt ſized rockets for this purpoſe are thoſe of 1lb.

## To divide the Tail of a Sky Rocket ſo as to form an Arch when aſcending.

Having ſome rockets made, and headed according to fancy, and tied on their ſticks; get ſome ſheet tin, and cut it into round pieces about 3 or 4 inches diameter; then on the ſtick of each rocket, under the mouth of the caſe, fix 1 of theſe pieces of tin, 16 inches from the rocket's neck, and ſupport it by a wooden bracket, as ſtrong as poſſible: the uſe of this is, that when the rocket is aſcending, the fire will play with great force on the tin, which will divide the tail in ſuch a manner, that it will form an arch as it mounts, and will have a very good effect when well managed: if there is a ſhort piece of port-fire, of a ſtrong charge, tied to the end of the ſtick, it will make a great addition; but this muſt be lighted before you fire the rocket.

To

## To make ſeveral Sky Rockets riſe in the ſame direction, and equally diſtant from each other.

Take 6 or any number of ſky rockets, of what ſize you pleaſe; then cut ſome ſtrong pack-thread into pieces of 3 or 4 yards long, and tie each end of theſe pieces to a rocket in this manner. Having tied one end of your pack-thread round the body of one rocket, and the other end to another; take a 2nd piece of pack-thread and make one end of it faſt to one of the rockets already tied, and the other end to a 3d rocket, ſo that all the rockets, except the 2 outſide, will be faſtened to 2 pieces of pack-thread: the length of thread from one rocket to the other, may be what the maker pleaſes; but the rockets muſt be all of a ſize, and their heads filled with the ſame weight of ſtars, rains, &c.

Having thus done, fix in the mouth of each rocket a leader of the ſame length; and, when you are going to fire them, hang them almoſt cloſe; then tie the ends of the leaders together, and prime them: this prime being fired, all the rockets will mount at the ſame time, and divide as far as the ſtrings will allow; which diviſion they will keep, provided they are all rammed alike, and well made. They are called, by ſome, Chained Rockets.

## Signal Sky Rockets

Are made of ſeveral kinds, according to the different ſignals intended to be given: but in Artificial Fireworks, 2 ſorts are only uſed, which are one with reports, and the other without; but thoſe for the uſe of the Navy and Army are headed with ſtars, ſerpents, &c.——Rockets which are to be bounced, muſt have their caſes made 1 ½ or 2 diameters longer than the common proportion, and

and, after they are filled, drive in a double quantity of clay; then bounce and pinch them, after the ufual manner, and fix on each a cap.

Signal fky rockets without bounces, are only fky rockets clofed and capped: thefe are very light, therefore do not require fuch heavy fticks as thofe with loaded heads; for which reafon, you may cut one length of the rocket off the ftick, or elfe make them thinner.

Signal rockets with reports, are fired in fmall flights; and oft both thefe, and thofe without reports, are ufed for a fignal to begin firing a collection of works.

## To fix two or more Sky Rockets on one ftick.

Two, 3, or 6 fky rockets, fixed on 1 ftick, and fired together, make a grand and beautiful appearance; for the tails of all will feem but as one of an immenfe fize, and the breaking of fo many heads at once will refemble the burfting of an air balloon; but the management of this device requires a fkilful hand; therefore, for the encouragement of thofe who are fond of curious performances, I fhall give fuch inftructions, that, if well obferved, even by thofe who have not made a great progrefs in this art, there will be no doubt of the rockets having the defired effect.

Rockets for this purpofe muft be made with the greateft exactnefs, all rammed by the fame hand, in the fame mould, and out of the one proportion of compofition; and after they are filled and headed, muft all be of the fame weight: the ftick muft alfo be well made, (and proportioned) to the following directions: firft, fuppofing your rockets to be ½ pounders, whofe fticks are 6 feet 6 inches long, then if 2, 3, or 6 of thefe are to be fixed on 1 ftick, let the length of it be 9 feet 9 inches; then cut the top of it into as many fides, as there are rockets, and let the length of each fide be equal to the length of 1 of the rockets without its head; and in each fide cut a groove, (as ufual); then from the grooves plane

plane it round, down to the bottom, where its thickneſs muſt be equal to half the top of the round part. As their thickneſs cannot be exactly aſcertained, I ſhall give a rule which generally anſwers for any number of rockets above two: the rule is this; that the ſtick at top muſt be thick enough, when the grooves are cut, for all the rockets to lie, without preſſing each other, though as near as poſſible.

When only 2 rockets are to be fixed on 1 ſtick, let the length of the ſtick be the laſt given proportion, but ſhaped after the common method, and the breadth and thickneſs, double the dimenſions given in the Table, page 50. The point of poiſe muſt be in the uſual place, (let the number of rockets be what they will:) if ſticks made by the above directions ſhould be too heavy, plane them thinner; and if too light, make them thicker; but always make them of the ſame length.

When more than two rockets are tied on one ſtick, there will be ſome danger of their flying up without the ſtick, unleſs the following precaution is taken; for caſes being placed on all ſides, there can be no notches for the cord which ties on the rockets to lie in; therefore, inſtead of notches, drive a ſmall nail, in each ſide of the ſtick, between the necks of the caſes; and let the cord, which goes round their necks, be brought cloſe under the nails; by this means the rockets will be as ſecure, as when tied on ſingly. Your rockets being thus fixed, carry a quick-match, without a pipe, from the mouth of one rocket to the other; this match being lighted will give fire to all at once.

Though the directions already given may be ſufficient for theſe rockets, I ſhall here add an improvement of my own, on a very eſſential part of this device, which is, that of hanging the rockets to be fired; for before I hit upon the following method, many of my eſſays proved unſucceſsful; but to prevent ſuch perplexities, inſtead of the old and common manner of hanging them on nails or hooks, make uſe of this contrivance: have a ring made of ſtrong iron wire, large enough

enough for the ſtick to go in, as far as the mouths of the rockets; then let this ring be ſupported by a ſmall iron, at ſome diſtance from the poſt or ſtand to which it is fixed; then have another ring, fit to receive and guide the ſmall end of the ſtick. Rockets thus ſuſpended will have nothing to obſtruct their fire; but when they are hung on nails or hooks, in ſuch a manner, that ſome of their mouths are againſt or upon a rail, there can be no certainty of their riſing in a vertical direction.

## To fire Sky-rockets without Sticks.

You muſt have a ſtand, of a block of wood, a foot diameter, and make the bottom flat, ſo that it may ſtand ſteady; in the centre of the top of this block draw a circle 2 ½ inches diameter, and divide the circumference of it into 3 = parts; then take 3 pieces of thick iron wire, each about 3 feet long, and drive them into the block, 1 at each point made on the circle; when theſe wires are drove in deep enough to hold them faſt, and upright, ſo that the diſtance from one to the other is the ſame at top as at bottom, the ſtand is complete.

The ſtand being thus made, prepare your rockets thus: take ſome common ſky-rockets, of any ſize, and head them as you pleaſe; then get ſome balls of lead, and tie to each a ſmall wire, 2 or 2 ½ feet long, and the other end of each wire tie to the neck of a rocket: theſe balls anſwer the purpoſe of ſticks, when made of a proper weight, which is about 2-3ds the weight of the rocket; but when they are of a proper ſize, they will balance the rocket in the ſame manner as a ſtick, at the uſual point of poiſe. To fire theſe, hang them, one at a time, between the tops of the wires, letting their heads reſt on the point of the wires, and the balls hang down between them: if the wires ſhould be too wide for the rockets, preſs them together, till they fit, and if too cloſe, force them open: the wires for this purpoſe muſt be ſoftened, ſo as not to have any ſpring,

or

or they will not keep their position, when preſſed cloſe or opened.

## Rain-falls for Sky-rockets, Double and Single.

Gold and ſilver rain compoſition are drove in caſes that are pinched quite cloſe at one end: if you roll them dry, 4 or 5 rounds of paper will be ſtrong enough, but if they are paſted, 3 rounds will do; and the thin ſort of cartridge paper is beſt for thoſe ſmall caſes, which in rolling you muſt not turn down the inſide edge, as in other caſes, for a double edge would be too thick for ſo ſmall a bore. The moulds for rain-falls ſhould be made of braſs, and turned very ſmooth in the inſide; or the caſes, which are ſo very thin, would tear in coming out; for the charge muſt be drove in tight; and the better the caſe fits the mould, the more driving it will bear. Theſe moulds have no nipple, but inſtead of which they are made flat: as it would be very tedious and troubleſome to ſhake the compoſition out of ſuch ſmall ladles, as are uſed for theſe caſes, it will be neceſſary to have a funnel, made of thin tin, to fit on the top of the caſe, by the help of which you may fill them very faſt. For ſingle rain-falls for 4 oz. rockets, let the diameter of the former be 2 16ths of an inch, and the length of the caſe 2 inches; for 8 oz. rockets, 4 16ths, and 2 diameters of the rocket long; for 1lb. rockets, 5 16ths, and 2 diameters of the rocket long; for 2 lb. rockets, 5 16ths, and 3 ½ inches long; for 4 lb. rockets, 6 16ths, and 4 ½ inches long; and for 6-pounders, 7 16ths diameter, and 5 inches long.

Of double rain-falls there are 2 ſorts; as, for example, ſome appear firſt like a ſtar, and then as rain; and ſome appear firſt as rain, and then like a ſtar: when you would have ſtars firſt, you muſt fill the caſes, within ½ an inch of the top, with rain compoſition, and the remainder with ſtar compoſition; but when you intend the rain ſhould be firſt, drive the caſe ½ an inch with ſtar compoſition,

and

the reſt with rain. By this method may be made many changes of fire; for in large rockets you may make them firſt burn as ſtars, then rain, and again as ſtars; or they may firſt ſhew rain, then ſtars, and finiſh with a report; but when they are thus managed, cut open the firſt-rammed end; after they are filled and bounced, at which place prime them. The ſtar compoſition for this puṛpoſe muſt be a little ſtronger than for rolled ſtars.

## Strung Stars.

Firſt take ſome thin paper, and cut it into pieces of 1 ½ inch ſquare, or thereabouts; then on each piece lay as much dry ſtar compoſition as you think the paper will eaſily contain; then twiſt up the paper as tight as you can; when done, rub ſome paſte on your hands, and roll the ſtars between them; then ſet them to dry: your ſtars being thus made, get ſome flax or fine tow, and roll a little of it over each ſtar; then paſte your hands and roll the ſtars as before, and ſet them again to dry; when they are quite dry, with a piercer make a hole through the middle of each, into which run a cotton quick-match, long enough to hold 10 or 12 ſtars, at 3 or 4 inches diſtance: but any number of ſtars may be ſtrung together by joining the match.

## Tailed Stars.

Theſe are called tailed ſtars, becauſe there are a great number of ſparks iſſue from them, which repreſent a tail like that of a comet. Of theſe there are two ſorts, which are Rolled and Drove: when rolled, they muſt be moiſtened with a liquor made of half a pint of ſpirit of wine, and half a gill of thin ſize, of this as much as will wet the compoſition enough to make it roll eaſy; when they are rolled, ſift meal powder over them, and ſet them to dry.

When tailed ſtars are drove, the compoſition muſt be moiſtened with ſpirit of wine only, and not made ſo

wet

wet as for rolling: 1 and 2 oz. cafes, rolled dry, are beft for this purpofe; and when they are filled, unroll the cafe within 3 or 4 rounds of the charge, and all that you unroll cut off; then pafte down the loofe edge: 2 or 3 days after the cafes are filled, cut them in pieces 5 or 6 8ths of an inch in length; then melt fome wax, and dip one end of each piece into it, fo as to cover the compofition: the other end muft be rubbed with meal powder wetted with fpirit of wine.

## Drove Stars.

Cafes for drove ftars are rolled with pafte, but are made very thin of paper: before you begin to fill them, damp the compofition with fpirit of wine that has had fome camphor diffolved in it; you may ram them indifferently hard, fo that you do not break, or fack the cafe, to prevent which, they fhould fit tight in the mould: they are drove in cafes of feveral fizes, from 8 drams to 4 oz. when they are filled in ½ oz. cafes, cut them in pieces of ¾ of an inch long; if 1 oz. cafes, cut them in pieces of 1 inch; if 2 oz. cafes, cut them in pieces of 1 ¼ inch long; and if 4 oz. cafes, cut them in pieces of 1 ½ inch long: having cut your ftars of a proper fize, prime both ends with wet meal powder. Thefe ftars are feldom put in rockets, they being chiefly intended for air balloons, and drove in cafes, to prevent the compofition from being broke by the force of the blowing powder in the fhell.

## Rolled Stars

Are commonly made about the fize of a mufket ball, though they are rolled of feveral fizes, from the bignefs of a piftol ball, to 1 inch diameter; and fometimes very fmall, but then called Sparks. Great care muft be taken in making ftars firft, that the feveral ingredients are reduced to a fine powder; fecondly, that the compofition is well worked and mixed. Before you begin to roll, take about a pound of compofition, and wet it with the following

following liquid, enough to make it ſtick together and roll eaſy; ſpirit of wine 1 quart, in which diſſolve $\frac{1}{4}$ of an ounce of iſinglaſs. If a great quantity of compoſition be wetted at once, the ſpirit will evaporate, and leave it dry, before you can roll it into ſtars: having rolled up one proportion, ſhake the ſtars in meal powder, and ſet them to dry, which they will do in 3 or 4 days; but if you ſhould want them for immediate uſe, dry them in an earthen pan over a ſlow heat, or in an oven. It being very difficult to make the ſtars all of an equal ſize, when the compoſition is taken up promiſcuouſly with the fingers; therefore I ſhall here ſet down a method by which you may make them very exact, which is,—When the mixture is moiſtened properly, roll it on a flat ſmooth ſtone, and cut it into ſquare pieces, making each ſquare large enough for the ſtars you intend. There is another method uſed by ſome to make ſtars, which is by rolling the compoſition in long pieces, and then cutting off the ſtar, ſo that each ſtar will be of a cylindrical form; but this method is not ſo good as the former, for to make the compoſition roll this way, it muſt be made very wet, which makes the ſtars heavy, as well as weakens them. All ſtars muſt be kept as much from air as poſſible, otherwiſe they will grow weak and bad.

## Scrolls for Sky Rockets.

Caſes for ſcrolls ſhould be made 4 or 5 inches in length, and their interior diameter 3 8ths of an inch: one end of theſe caſes muſt be pinched quite cloſe, before you begin to fill, and when filled, cloſe the other end; then in the oppoſite ſides make a ſmall hole at each end, to the compoſition, in the ſame manner as in Tourbillons; and prime them with wet meal powder. You may put in the head of a rocket as many of theſe caſes as it will contain: being fired they turn very quick in the air, and form a ſcroll or ſpiral line. They are generally filled with a ſtrong charge, as that of ſerpents, or brilliant fire.

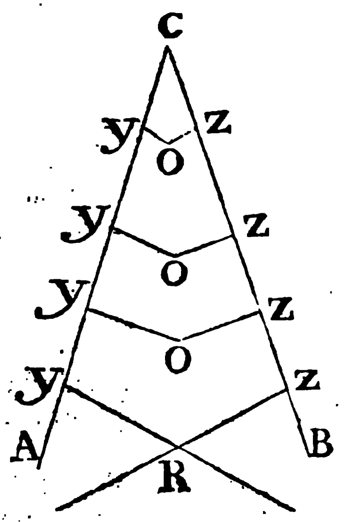
Swarmers,

## Swarmers, or ſmall Rockets.

Rockets that go under the denomination of Swarmers, are thoſe from 2 oz. downwards. Theſe rockets are fired ſometimes in flights, and in large water-works, &c. Swarmers of 1 and 2 oz. are bored, and made in the ſame manner as large rockets, except, when headed, their heads muſt be put on without a collar: the number of ſtrokes for driving 1 oz. muſt be eight; and for 2 oz. twelve.

All rockets under 1 oz. are not bored, but muſt be filled to the uſual height with compoſition, which is generally compoſed of fine meal powder 4 oz. and charcoal or ſteel duſt 2 drams: the number of ſtrokes for ramming theſe ſmall ſwarmers is not material, ſo as they are rammed true, and moderately hard. The necks of unbored rockets muſt be in the ſame proportion as in common caſes.

## The cauſe of Sky Rockets riſing.




Having promiſed, in the ſecond ſection, to prove that the effect of ſky rockets, and proportion of their charge, depends on the ſize of the cavity in the compoſition; I ſhall here endeavour to give a mathematical demonſtration thereof.

Let

Let ABC be the hollow cone for the fire, AYCZB, the ſuperficies of that cone, all the lines OZ at right angles with BC, all the lines OY at right angles with AC: now all the angles ZOY being towards R, whether the angles ZOY are obtuſe or acute, but the more acute the better. The rays of fire ZO and YO iſſuing from the ſides of the cone BC and AC, and continually acting with the greater force one upon another at O, forcing the whole BCA upward from the point R; and the wider the cone is, (ſo as not to exceed one third at bottom, and one ſixth at top, of the exterior diameter of the rocket) the greater velocity will the rocket riſe with.

## Stands for Sky Rockets.

Care muſt be taken, in placing the rockets, when they are to be fired, to give them a vertical direction at their firſt ſetting out; which may be managed thus. Have 2 rails of wood, of any length, ſupported at each end by a perpendicular leg, ſo that the rails be horizontal, and let the diſtance from one to the other be almoſt equal to the length of the ſticks of the rockets intended to be fired; then in the front of the top rail drive ſquare hooks at 8 inches diſtance, with their points turning ſideways, ſo that when the rockets are hung on them, the points will be before the ſticks, and keep them from falling, or being blown off by the wind: in the front of the rail at bottom muſt be ſtaples, drove perpendicular under the hooks at top; through theſe ſtaples put the ſmall ends of the rocket ſticks. Rockets are fired by applying a lighted port fire to their mouths.

N. B. When ſky rockets are made to perfection, and fired, they will ſtand 2 or 3 ſeconds on the hook before they riſe, and then mount up briſkly, with a ſteady motion, carrying a large tail from the ground all the way up, and, juſt as they turn, break and diſperſe the ſtars.

## Girandole Cheſts, for flights of Rockets,

Are generally compoſed of four ſides, of equal dimenſions; but may be made of any diameter, according to the

the number of rockets deſigned to be fired; its height muſt be in proportion to the rockets, but muſt always be a little higher than the rockets with their ſticks. When the ſides are joined, fix in the top, as far down the cheſt as the length of one of the rockets with its cap on. In this top, make as many ſquare or round holes to receive the rocket ſticks, as you intend to have rockets; but let the diſtance between them be ſufficient for the rockets to ſtand without touching one another; then from one hole to another cut a groove, large enough for a quick-match to lie in: the top being thus fixed, put in the bottom, at about 1 ½ foot diſtance from the bottom of the cheſt; in this bottom muſt be as many holes as in the top, and all to correſpond; but theſe holes need not be ſo large as thoſe in the top.

To prepare your cheſt, you muſt lay a quick-match, in all the grooves, from hole to hole; then take ſome ſky rocke s, and rub them in the mouth with wet meal powder, and put a bit of match up the cavity of each, which match muſt be long enough to hang a little below the mouth of the rocket. Your rockets and cheſt being prepared according to the above directions, put the ſticks of the rockets through the holes in the top and bottom of the cheſt, ſo that their mouths may reſt on the quick-match in the grooves; by which all the rockets will be fired at once; for by giving fire to any part of the match, it will communicate to all the rockets in an inſtant. As it would be rather troubleſome to direct the ſticks from the top to the proper holes in the bottom, it will be neceſſary to have a ſmall door in one of the ſides, which when opened, you may ſee how to place the ſticks. Flights of rockets, being ſeldom fired at the beginning of any fireworks, for which reaſon they are in danger of being fired by the ſparks from wheels, &c. therefore to preſerve them, a cover ſhould be made to fit on the cheſt, and the door in the ſide kept ſhut.

## Serpents or Snakes for Pots of Aigrettes, Small Mortars, Sky Rockets, &c.

Serpents for this uſe are made from 2 ½ inches, to 7 inches long, and their formers from 3 16ths to 5 8ths of an inch diameter; but the diameter of the caſes muſt always be equal to 2 diameters of the former; they are rolled and choaked like other caſes, and filled with compoſition from 5 8ths of an inch, to 1 ½ inch high, according to the ſize of the mortars, or rockets, they are deſigned for, and the remainder of the caſes bounced with corn-powder, and afterwards their ends pinched and tied cloſe: before they are uſed, their mouths muſt be primed with wet meal-powder.

## Leaders, or Pipes of Communication.

The beſt paper for leaders, is Elephant, which you cut into long ſlips, 2 or 3 inches broad, ſo that they may go 3 or 4 times round the former, but not more: when they are very thick, they are too ſtrong for the paper which faſtens them to the works, and will ſometimes fly off without leading the fire. The formers for theſe leaders are made from 2 to 6 16ths of an inch diameter; but 4 16ths is the ſize generally made uſe of: the formers are made of ſmooth braſs wire: when you uſe them, rub them over with greaſe, or keep them wet with paſte, to prevent their ſticking to the paper, which muſt be paſted all over. In rolling of pipes, make uſe of a rolling-board, but uſe it lightly: having rolled a pipe, draw out the former with one hand, holding the pipe as light as poſſible with the other; for, if it preſs againſt the former, it will ſtick and tear the paper.

N. B. Make your leaders of different lengths, or in clothing of works you will cut a great many to waſte. Leaders for marron batteries muſt be made of ſtrong cartridge paper.

SECT.

## SECT. V. Aquatic Fireworks.

WORKS that ſport in the water are much eſteemed by moſt admirers of fireworks, particularly water rockets; but, as they ſeem of a very extraordinary nature to thoſe who are acquainted with this art, I ſhall endeavour to explain the method of making them, in as full and eaſy a manner as poſſible, as well as other devices for the water.

### Water Rockets

May be made from 4 oz. to 2 lb. but, if larger, are too heavy; ſo that it will be difficult to make them keep above water without a cork float, which muſt be tied to the neck of the caſe; but the rockets will not dive ſo well with, as without floats.

Caſes for theſe are made in the ſame manner and proportion as ſky rockets, only a little thicker of paper. When you fill them which are drove ſolid, put in firſt 1 ladle-full of ſlow fire, then 2 of the proper charge and on that 1 or 2 ladles of ſinking charge, then the proper charge, then the ſinking charge again, and ſo on, till you have filled the caſe within 3 diameters; then drive on the compoſition 1 ladle-full of clay; through which make a ſmall hole to the charge; then fill the caſe, within ½ a diameter, with corn powder, on which turn down 2 or 3 rounds of the caſe in the inſide; then pinch and tie the end very tight: having filled your rockets, (according to the above directions) dip their ends in melted roſin, or ſealing wax, or elſe ſecure them well with greaſe. When you fire theſe rockets, throw in 6 or 8 at a time; but, if you would have them all ſink, or ſwim, at the ſame time, you muſt drive them with an equal quantity of compoſition, and fire them all together.

 To

## To make Pipes of Communication, which may be ufed under Water.

Pipes for this purpofe muft be a little thicker of paper than thofe for land. Having rolled a fufficient number of pipes, and kept them till dry, wafh them over with drying oil, and fet them to dry; but when you oil them, leave about 1½ inch at each end dry, for joints: if they were oiled all over, when you come to join them, the pafte would not ftick where the paper is greafy: after the leaders are joined, and the pafte dry, oil the joints. Thefe pipes will lie many hours under water, without receiving any damage.

## Horizontal Wheels for the Water.

Firft get a large wooden bowl without a handle; then have an octagon wheel made of a flat board, 18 inches diameter, fo that the length of each fide will be near 7 inches: in all the fides cut a groove for the cafes to lie in. This wheel being made, nail it on the top of the bowl; then take 8 four-ounce cafes, filled with a proper charge, each about 6 inches in length. Now, to clothe the wheel with thefe cafes, get fome whitifh-brown paper, and cut it into flips 4 or 5 inches broad, and 7 or 8 long: thefe flips being pafted all over on one fide, take 1 of the cafes, and roll 1 of the flips of paper about 1½ inch on its end, fo that there will remain about 2½ inches of the paper hollow from the end of the cafe: this cafe tie on 1 of the fides of the wheel, near the corners of which muft be holes bored, through which you put the pack-thread to tie the cafes: having tied on the firft cafe at the neck and end, put a little meal powder in the hollow paper; then pafte a flip of paper on the end of another cafe, the head of which put into the hollow paper on the firft, allowing a fufficient diftance, from the tail of one to the head of the other, for the pafted paper to bend without tearing; the fecond cafe tie on as you did the firft;

firſt; and ſo on with the reſt, except the laſt, which muſt be cloſed at the end, unleſs it is to communicate to any thing on top of the wheel; ſuch as fire-pumps or brilliant fires, fixed in holes, cut in the wheel, and fired by the laſt or ſecond caſe, as the fancy directs: 6, 8, or any number, may be placed on the top of the wheel, ſo that they are not too heavy for the bowl.

Before you tie on the caſes, cut the upper part of all their ends, except the laſt, a little ſhelving, that the fire from one may play over the other, without being obſtructed by the caſe. Wheel caſes have no clay drove in their ends, nor pinched, but are always left open, only the laſt, or thoſe which are not to lead fire, which muſt be well ſecured.

## Water Mines.

For theſe mines you muſt have a bowl, with a wheel on it, made in the ſame manner as the water wheel, only in its middle muſt be a hole, of the ſame diameter you deſign to have the mine. Theſe mines are tin pots, with ſtrong bottoms, and a little more than 2 diameters in length: your mine muſt be fixed in the hole in the wheel, with its bottom reſting on the bowl; then loaded with ſerpents, crackers, ſtars, ſmall water rockets, &c. in the ſame manner as pots of aigrettes; but in their centre fix a caſe of Chineſe fire, or a ſmall gerbe, which muſt be lighted at the beginning of the laſt caſe on the wheel. Theſe wheels are to be clothed as uſual.

## Fire Globes for the Water.

Bowls for water globes muſt be very large, and the wheels on them of a decagon form; on each ſide of which nail a piece of wood 4 inches long, and on the outſide of each piece cut a groove, wide enough to receive about $\frac{1}{4}$ of the thickneſs of a 4 oz. caſe: theſe pieces of wood muſt be nailed in the middle of each face of the wheel, and fixed in an oblique direction, ſo that the fire from the caſes may incline upwards: the wheel

being thus prepared, tie in each groove a 4 oz. caſe, filled with a grey charge; then carry a leader from the tail of one caſe to the mouth of the other.

Globes for theſe wheels are made of 2 tin hoops, with their edges outwards, fixed one within the other, at right angles. The diameter of theſe hoops muſt be ſomewhat leſs than that of the wheel. Having made a globe, drive in the centre of a wheel an iron ſpindle, which muſt ſtand perpendicular, and its length 4 or 6 inches more than the diameter of the globe.

This ſpindle ſerves for an axis, on which the globe is fixed, which, when done, muſt ſtand 4 or 6 inches from the wheel: round one ſide of each hoop muſt be ſoldered little bits of tin, 2 ½ inches diſtance from each other; which pieces muſt be 2 inches in length each, and only faſtened at one end, the other ends being left looſe, to turn round the ſmall port fires, and hold them on: theſe port fires muſt be made of ſuch a length, as will laſt out the caſes on the wheel. You are to obſerve, that there need not be any port fires at the bottom of the globe within 4 inches of the ſpindle; for, if there were, they would have no effect, but only burn the wheel: all the port fires muſt be placed perpendicular from the centre of the globe, with their mouths outwards; and muſt all be clothed with leaders, ſo as all to take fire with the ſecond caſe of the wheel; which caſes muſt burn 2 at a time, 1 oppoſite the other. When 2 caſes of a wheel begin together, 2 will end together; therefore the 2 oppoſite end caſes muſt have their ends pinched and ſecured from fire. The method of firing ſuch wheels is, by carrying a leader from the mouth of one of the firſt caſes, to that of the other, which leader being burnt through the middle, will give fire to both at the ſame time.

## Odoriferous Water Ballóóns.

Theſe ballóóns are made in the ſame manner, as air ballóóns, but very thin of paper, and in diameter 1 ¾ inch with a vent of ½ an inch diameter. The ſhells being made,

made, and quite dry, fill them with any of the following compofitions, which muft be rammed in tight: thefe balloons muft be fired at the vent, and put into a bowl of water. Odoriferous works are generally fired in rooms.

## Compofition I.

Saltpetre 2 oz. flower of fulphur 1 oz. camphor ½ oz. yellow amber ½ oz. charcoal duft ¾ oz. flower of benjamin, or affa odorata, ½ oz. all powdered very fine, and well mixed.

## Compofition II.

Saltpetre 12 oz. meal powder 3 oz. frankincenfe 1 oz. myrrh ½ oz. camphor ½ oz. charcoal 3 oz. all moiftened with the oil of fpike.

## Compofition III.

Saltpetre 2 oz. fulphur ½ oz. antimony ½ oz. amber ½ oz. cedar rafpings ½ oz. all mixed with the oil of rofes, and a few drops of bergamot.

## Compofition IV.

Saltpetre 4 oz. fulphur 1 oz faw-duft of juniper ½ oz. faw-duft of cyprefs 1 oz. camphor ½ oz. myrrh 2 drams, dried rofemary ½ oz. cortex elaterii ½ oz. all moiftened a little with the oil of rofes

N. B. Water rockets may be made with any of the above compofitions, with a little alteration, to make them weaker or ftronger, according to the fize of the cafes.

## Water Balloons.

Having made fome thin paper fhells, of what diameter you pleafe, fill fome with the compofition for water balloons, and fome after this manner. Having made the

with crackers, which mortar muſt be fired by a pipe from the end of the ſlow fire; the firing of this mortar will ſink the ſhip, and make a pretty concluſion. The regulating port fire of this ſhip muſt be lighted at the ſame time with the firſt fighting ſhip.

Having prepared all the ſhips for fighting, we ſhall next proceed with the management of them, when on the water. At one end of the pond, juſt under the ſurface of the water, fix 2 running blocks, at what diſtance you chuſe the ſhips ſhould fight; and at the other end of the pond, oppoſite to each of theſe blocks, under the water, fix a double block; then on the land, by each of the double blocks, place two ſmall windlaſſes; round one of them turn one end of a ſmall cord, and the other end put through one of the blocks; then carry it through the ſingle one, at the oppoſite end of the pond, and bring it back through the double block again, and round the other windlaſs: to this cord, near the double block, tie as many ſmall ſtrings, as half the number of the ſhips, at what diſtance you think proper; but theſe ſtrings muſt not be more than 2 feet each: the looſe end of each make faſt to a ſhip, juſt under her bow-ſprit; but if tied to the keel, or too near the water, it will overſet the ſhip. Half the ſhips being thus prepared, near the other double block fix two more windlaſſes, to which faſten a cord, and to it tie the other half of the ſhips, as before: when you fire the ſhips, pull in the cord, with one of the windlaſſes, to get all the ſhips together; and when you have ſet fire to the firſt, turn that windlaſs, which draws them out, and ſo on with the reſt, till they are all out, in the middle of the pond; then by turning the other windlaſs, you will draw them back again; by which method you may make them change ſides, and tack about, backwards and forwards, at pleaſure. For the fire-ſhip, fix the blocks and windlaſſes between the others, ſo that when ſhe ſails out, ſhe will be between the other ſhips: you muſt not let this ſhip advance, till the guns at her ports take fire.

To

that [illegible] rigging [illegible] composition [illegible] the number [illegible] of the [illegible] method of firing [illegible] from the [illegible] must make their [illegible] calculating the [illegible] regulating cases, [illegible] When [illegible] carried [illegible] the ship, which management [illegible] will be very slow [illegible] guns [illegible] hours.

Having [illegible] in regulating the guns [illegible] make all the [illegible] with the [illegible] when [illegible] begin the engagement, light one [illegible] and [illegible] lending them [illegible] which will make them fire regularly at different times, [illegible] the time between the firing of each gun will be equal to that of lighting the [illegible].

The fire [illegible] need not be very good, for [illegible] action. To prepare a ship for this purpose, make a port fire equal [illegible] with them [illegible] and place it [illegible] in every port place a large port fire, filled with a very strong composition, [illegible] and let them all be fired at once by a leader from the [illegible] fire, [illegible] diameters of the [illegible] along both sides, on the top of the upper deck, lay [illegible] composition about ½ an inch thick and [illegible] broad, which must be wetted with thin size, then primed with meal powder, and secured from fire by pasting paper over it; on the place where you lay this composition, drive some little tacks with flat heads, to hold it fast to the deck; this must be fired just after the sham guns, and when burning will shew a flame all round the ship: at the head take up the decks, and put in a tin mortar [illegible]

[illegible]

each noſtril put a ſmall caſe filled half with grey charge, and the reſt with port-fire compoſition.

If Neptune is to give fire to any building on the water; at his firſt ſetting out, the wheels of the chariot, and that on his head, with the white flames on the horſes heads, and the port fires in their eyes and noſtrils, muſt all be lighted at once; then from the bottom of the white flames carry a leader to the trident. As Neptune is to advance by the help of a block and cord, you muſt manage it ſo as not to let him turn about, till the brilliant fires on the horſes, and the trident, begin; for it is by the fire from the horſes, (which plays almoſt upright) that the building, or work, is lighted; which muſt be thus prepared. From the mouth of the caſe, which is to be firſt fired, hang ſome looſe quick-match, to receive the fire from the horſes. When Neptune is only to be ſhewn by himſelf, without ſetting fire to any other works; let the white flames on the horſes be very ſhort, and not to laſt longer than one caſe of each wheel, and let 2 caſes of each wheel burn at a time.

## Swans and Ducks in Water.

If you would have the ſwans, or ducks, diſcharge rockets into the water, they muſt be made hollow, and of paper, and filled with ſmall water rockets, with ſome blowing powder, to throw them out; but if this is not done, they may be made of wood, which will laſt many times. Having made and painted ſome ſwans, fix them on floats; then in the places where their eyes ſhould be, bore holes two inches deep, inclining downwards, and wide enough to receive a ſmall port fire; the port fire caſes for this purpoſe muſt be made of braſs, 2 inches long, and filled with a ſlow bright charge; in the middle of one of theſe caſes make a little hole, then put the port fire in the eye hole of the ſwan, leaving about half an inch to project out, and in the other eye put another port fire, with a hole made in it; then in the neck of the ſwan, within two inches of one of the eyes, bore

bore a hole ſlantways, to meet that in the port fire; in this hole put a leader, and carry it to a water rocket, that muſt be fixed under the tail with its mouth upwards; on the top of the head place 2 one-ounce caſes, 4 inches long each, drove with brilliant fire; one of theſe caſes muſt incline forwards, and the other backwards; theſe muſt be lighted at the ſame time as the water rocket; to do which, bore a hole between them, in the top of the ſwan's head, down to the hole in the port fire, to which carry a leader; if the ſwan is filled with rockets, they muſt be fired by a pipe, from the end of the water rocket under the tail. When you ſet the ſwan a ſwimming, light the 2 eyes.

## Water Fire-Fountains.

To make a fire fountain, you muſt firſt have a float made of wood, 3 feet diameter, then in the middle fix a round perpendicular poſt, 4 feet high, and 2 inches diameter; round this poſt fix 3 circular wheels, made of thin wood, without any ſpokes. The largeſt of theſe wheels muſt be placed within 2 or 3 inches of the float, and muſt be nearly of the ſame diameter. The 2d wheel muſt be 2 feet 2 inches diameter, and fixed at 2 feet diſtance from the firſt. The 3d wheel muſt be 1 foot 4 inches diameter, and fixed within 6 inches of the top of the poſt: the wheels being fixed, take 18 four or 8 ounce caſes, of brilliant fire, and place them round the firſt wheel, with their mouths outwards, and inclining downwards; on the 2d wheel place 13 caſes of the ſame, and in the ſame manner, as thoſe on the firſt; on the 3d place 8 more of theſe caſes, in the ſame manner as before, and on the top of the poſt fix a gerbe; then clothe all the caſes with leaders, ſo that both they and the gerbe may take fire at the ſame time. Before you fire this work, try it in the water, to ſee if the float is properly made, ſo as to keep the fountain upright.

SECT.

## Marron Batteries,

If well managed, will keep time to a march, or a flow piece of mufic. Marron batteries are made of feveral ftands, with a number of crofs rails, for the marrons, which are regulated by leaders, by cutting them of different lengths, and nailing them tight, or loofe, according to the time of the mufic. In marron batteries you muft ufe the large and fmall marrons, and the nails for the pipes muft have flat heads.

## Line Rockets

Are made and drove as the fky rockets, but have no heads; and the cafes muft be cut clofe to the clay; they are fometimes made with 6 or 7 changes, but in general not more than 4 or 5: the method of managing thofe rockets is,—Firft, have a piece of light wood, the length of 1 of the rockets, turned round about 2 ½ inches diameter, with a hole through the middle lengthwife, large enough for the line to go eafily through: if you defign 4 changes, have 4 grooves cut in the fwivel, one oppofite the other, to lay the rockets in.

The mouths of the rockets being rubbed with wet meal powder, lay them in the grooves, head to tail, and tie them faft; from the tail of the firft rocket carry a leader to the mouth of the fecond, and from the fecond to the third, and fo on to as many as there are on the fwivel, making every leader very fecure; but in fixing thefe pipes, take care that the quick-match does not enter the bores of the rockets: the rockets being fixed on the fwivel, and ready to be fired, have a line 100 yards long, ftretched and fixed up tight, at any height from the ground; but be fure to place it horizontal: this length of line will do for ½ lb. rockets; but, if larger, the line muft be longer: before you put up the line, put one end of it through the fwivel, and when you fire the line rocket, let the mouth of that rocket which you fire firft, face that end of the line where you ftand; then the firft rocket

rocket will carry the reſt to the other end of the line, and the ſecond will bring them back, and ſo they will run out and in according to the number of rockets: at each end of the line, there muſt be a piece of flat wood, for the rocket to ſtrike againſt, or its force will cut the line. Let the line be well ſoaped, and the hole in the ſwivel very ſmooth.

## Different Decorations for Line Rockets.

To line rockets may be fixed great variety, ſuch as flying dragons, mercuries, ſhips, &c. Or they may be made to run on the line like a wheel, which is done in this manner. Have a flat ſwivel, made very exact, and on it tie two rockets obliquely, one on each ſide, which will make it turn round all the way it goes, and form a circle of fire; the charge for theſe rockets ſhould be a little weaker than common; if you would ſhew 2 dragons fighting, get 2 ſwivels made ſquare, and on each tie 3 rockets together, on the under ſide; then have 2 flying dragons made of tin, and fix one of them on the top of each ſwivel, ſo as to ſtand upright; in the mouth of each dragon put a ſmall caſe of common fire, and another at the end of the tail; you may put 2 or 3 port fires, of a ſtrong charge, on 1 ſide of their bodies, to ſhew them. This done, put them on the line, one at each end; but let there be a ſwivel in the middle of the line, to keep the dragons from ſtriking together: before you fire the rockets light the caſes on the dragons, and if care be taken in firing both at the ſame time, they will meet in the middle of the line, and ſeem to fight. Then they will run back, and return with great violence; which will have a very pleaſing effect. The line for theſe rockets muſt be very long, or they will ſtrike too hard together.

## Chineſe Flyers.

Caſes for flyers may be made of different ſizes, from 1 to 8 ounces: they muſt be made thick of paper, and 8 interior diameters long; they are rolled in the ſame

manner as tourbillons, with a ſtraight paſted edge, and pinched cloſe at one end. The method of filling them is, the caſe being put in a mould, whoſe cylinder, or foot, muſt be flat at top without a nipple, fill it within ½ a diameter of the middle; then ram in ½ a diameter of clay, on that as much compoſition as before, on which drive ½ a diameter of clay; then pinch the caſe cloſe, and drive it down flat; after this is done bore a hole exactly through the centre of the clay in the middle; then in the oppoſite ſides at both ends make a vent, and in that ſide you intend to fire firſt make a ſmall hole to the compoſition near the clay in the middle, from which carry a quick match, covered with a ſingle paper, to the vent at the other end; then when the charge is burnt on one ſide, it will, by means of the quick match, communicate to the charge in the other, (which may be of a different ſort). The flyers being thus made, put an iron pin, that muſt be fixed in the work on which they are to be fired, and on which they are to run: through the hole in the middle, on the end of this pin, muſt be a nut to keep the flyer from running off. If you would have them turn back again after they are burnt, make both the vents at the ends on the ſame ſide, which will alter its courſe the contrary way.

## Table Rockets

Are deſigned merely to ſhew the truth of driving, and the judgement of a fire worker, they having no other effect, when fired, than ſpinning round, in the ſame place where they begin, till they are burnt out, and ſhewing nothing more than an horizontal circle of fire.

The method of making theſe rockets is—Have a cone turned out of hard wood, 2 ½ inches diameter, and as much high; round the baſe of it draw a line; on this line fix 4 ſpokes, 2 inches long each, ſo as to ſtand one oppoſite the other; then fill 4 nine-inch 1lb. caſes, with any ſtrong compoſition, within 2 inches of the top: theſe caſes are made like tourbillons, and muſt be rammed with the greateſt exactneſs.

Your rockets being filled, fix their open ends on the ſhort ſpokes; then in the ſide of each caſe bore a hole

hole near the clay; all theſe holes, or vents, muſt be ſo made that the fire of each caſe may act the ſame way; from theſe vents carry leaders to the top of the cone, and tie them together. When you would fire the rockets, ſet them on a ſmooth table, and light the leaders in the middle, and all the caſes will fire together (ſee Fig. 38.) and ſpin on the point of the cone.

Theſe rockets may be made to riſe like tourbillons, by making the caſes ſhorter, and boring 4 holes in the under ſide of each at equal diſtances: this being done, they are called Double Tourbillons.

Note, all the vents in the under ſide of the caſes muſt be lighted at once; and the ſharp point of the cone cut off, at which place make it ſpherical.

## To make Wheels and other Works incombuſtible.

It being neceſſary, when your works are new, to paint them of ſome dark colour; therefore, if inſtead of which, you make uſe of the following compoſition, it will give them a good colour, and in a great meaſure prevent their taking fire ſo ſoon as if painted. Take brick duſt, coal aſhes, and iron filings, of each an equal quantity, and mix them with a double ſize, made hot. With this waſh over your works, and when dry waſh them over again; this will preſerve the wood greatly againſt fire. Let the brick-duſt and aſhes be beat to a fine powder.

## Single Vertical Wheels.

There are different ſorts of vertical wheels, ſome having their fells of a circular form, others of an hexagon, octagon, or decagon form, or any number of ſides, according to the length of the caſes you deſign for the wheel: your ſpokes being fixed in the nave, nail ſlips of tin, with their edges turned up, ſo as to form grooves for the caſes to lie in, from the end of one ſpoke to another; then tie your caſes in the grooves, head to tail, in the

H 2 ſame

fame manner as thofe on the horizontal water wheel, fo that the cafes fucceffively taking fire from one another, will keep the wheel in an equal rotation. Two of thefe wheels are very oft fired together, one on each fide of a building, and both lighted at the fame time, and all the cafes filled alike, to make them keep time together, which they will do if made by the following directions. In all the cafes of both wheels, except the firft, on each wheel, drive 2 or 3 ladles full of flow fire, in any part of the cafes; but be careful to ram the fame quantity in each cafe, and in the end of one of the cafes, on each wheel, you may ram 1 ladle full of dead fire compofition, which muft be very lightly drove; you may alfo make many changes of fire, by this method.

Let the hole in the nave of the wheel be lined with brafs, and made to turn on a fmooth iron fpindle. On the end of this fpindle let there be a nut, to fcrew off and on; when you have put the wheel on the fpindle, fcrew on the nut, which will keep the wheel from flying off. Let the mouth of the firft cafe be a little raifed. See fig. 39. Vertical wheels are made from 10 inches to 3 feet diameter, and the fize of the cafes muft differ accordingly; 4 oz. cafes will do for wheels of 14 or 16 inches diameter, which is the proportion generally ufed. The beft wood for wheels of all forts, is a light and dry beech.

## Horizontal Wheels

Are beft when their fells are made circular; in the middle of the top of the nave muft be a pintle, turned out of the fame piece as the nave, 2 inches long, and equal in diameter to the bore of 1 of the cafes of the wheel: there muft be a hole bored up the centre of the nave, within $\frac{1}{2}$ an inch of the top of the pintle. The wheel being made, nail at the end of each fpoke (of which there fhould be 6 or 8) a piece of wood, with a groove cut in it to receive the cafe. Thefe pieces fix in fuch a manner, that half the cafes may incline upwards, and half

half downwards, and that when they are tied on, their heads and tails may come very near together: from the tail of one cafe to the mouth of the other carry a leader, which fecure with pafted paper. Befides thefe pipes, it will be neceffary to put a little meal powder infide the pafted paper, to blow off the pipe, that there may be no obftruction to the fire, from the cafes. By means of thefe pipes, the cafes will fucceffively take, burning one upwards, and the other downwards. On the pintle fix a cafe of the fame fort as thofe on the wheel; this cafe muft be fired by a leader, from the mouth of the laft cafe on the wheel, which cafe muft play downwards: inftead of a common cafe in the middle, you may put a cafe of Chinefe fire, long enough to burn as long as 2 or 3 of the cafes on the wheel.

Horizontal wheels are oft fired 2 at a time, and made to keep time, like vertical wheels; only they are made without any flow or dead fire; 10 or 12 inches will be enough for the diameter of wheels with 6 fpokes. Fig. 40. reprefents a wheel on fire, with the firft cafe burning.

## Spirali Wheels

Are only double horizontal wheels, and made thus: The nave muft be about 6 inches long, and fomewhat thicker than the fingle fort; inftead of the pintle at top, make a hole for the cafe to be fixed in; and 2 fets of fpokes, one fet near the top of the nave, and the other near the bottom. At the end of each fpoke cut a groove, wherein you tie the cafes, there being no fell; the fpokes fhould not be more than 3 ½ inches long each from the nave, fo that the wheel may not be more than 8 or 9 inches diameter; the cafes are placed in fuch a manner, that thofe at top play down, and thofe at bottom play up, but let the 3d or 4th cafe play horizontally. The cafe in the middle may begin with any of the others, you pleafe: 6 fpokes will be enough for each fet, fo that the wheel may confift of 12 cafes, befides that on the top: the cafes 6 inches each.

## Plural Wheels

Are made to turn horizontally, and to confift of 3 fets of fpokes, placed 6 at top, 6 at bottom, and 4 in the middle, which muft be a little fhorter than the reft: let the diameter of the wheel be 10 inches; the cafes muft be tied on the ends of the fpokes, in grooves cut on purpofe, or in pieces of wood nailed on the ends of the fpokes, with grooves cut in them as ufual: in clothing thefe wheels, make the upper fet of cafes play obliquely downwards, and them at bottom obliquely upwards, and them in the middle horizontally. In placing the leaders, you muft order it fo that the cafes may burn thus, viz. firft up, then down, then horizontal, and fo on with the reft; but another change may be made, by driving in the end of the eighth cafe, 2 or 3 ladles full of flow fire, to burn till the wheel has ftopped its courfe; then let the other cafes be fixed the contrary way, which will make the wheel run back again: for the cafe at top you may put a fmall gerbe; and let the cafes on the fpokes be fhort, and filled with a ftrong brilliant charge.

## Illuminated Spiral Wheel.

Firft have a circular horizontal wheel, made 2 feet diameter, with a hole quite through the nave; then take 3 thin pieces of deal, 3 feet long each, and ¾ of an inch broad each: one end of each of thefe pieces nail to the fell of the wheel, at an equal diftance from one another, and the other end nail to a block with a hole in its bottom, which muft be perpendicular with that in the block of the wheel, but not fo large. The wheel being thus made, have a hoop planed down very thin and flat; then nail one end of it to the fell of the wheel, and wind it round the 3 fticks in a fpiral line, from the wheel to the block at top: on the top of this block fix a cafe of Chinefe fire; on the wheel you may place any number of cafes, which muft incline downwards, and burn 2 at a time. If the wheel fhould confift of 10 cafes, you may let the illuminations

and

and Chinese fire begin with the second cases. The spindle for this wheel must be a little longer than the cone, and made very smooth at top, on which the upper block is to turn, and the whole weight of the wheel to rest. See Fig. 41.

## Double Spiral Wheel.

For this wheel the block, or nave, must be as long as the height of the worms, or spiral lines, but must be made very thin, and as light as possible. In this block must be fixed several spokes, which must diminish in length, from the wheel to the top, so as not to exceed the surface of a cone of the same height. To the ends of these spokes nail the worms, which must cross each other several times: these worms clothe with illuminations, the same as those on the single wheels; but the horizontal wheel you may clothe as you like. At top of the worm place a case of spur-fire, or an amber light. See Fig. 42. This figure is shewn without leaders, to prevent a confusion of lines.

## Ballóón Wheels

Are made to turn horizontally: they must be made 2 feet diameter, without any spokes, and very strong, with any number of sides. On the top of a wheel range and fix tin pots, 3 inches diameter, and 7 inches high each, as many of these as there are cases on the wheel: near the bottom of each pot make a small vent; into each of these vents carry a leader from the tail of each case; some of the pots load with stars, and some with serpents, crackers, &c. As the wheels turn, the pots will successively be fired, and throw into the air a great variety of fires.

## Fruiloni Wheels.

First have a nave made 9 inches long, and 3 in diameter: near the bottom of this nave fix 8 spokes, with a

hole in the end of each, large enough to receive a 2 or 4 ounce caſe: each of theſe ſpokes may be 14 inches long from the block. Near the top of this block fix 8 more of the ſame ſpokes, exactly over the others, but not ſo long by 2 inches. As this wheel is to run horizontally, all the caſes in the ſpokes at top muſt play obliquely upwards, and all them in the ſpokes at bottom obliquely downwards. This being done, have a ſmall horizontal wheel made with 8 ſpokes, each 5 inches long from the block: on the top of this wheel place a caſe of brilliant fire: all the caſes on this wheel muſt play in an oblique direction downwards, and burn 2 at a time, and theſe on the large wheel 4 at a time; that is, 2 of thoſe in the top ſet of ſpokes, and 2 of them in the bottom ſet of ſpokes.

The 4 firſt caſes on the large wheel, and the 2 firſt on the ſmall, muſt be fired at the ſame time, and the brilliant fire at top, at the beginning of the laſt caſes. The caſes of the wheels may be filled with a grey charge. When theſe wheels are completed, you muſt have a ſtrong iron ſpindle, made 4 feet 6 long, and fixed perpendicular on the top of a ſtand: on this put the large wheel, whoſe nave muſt have a hole quite through from the bottom to the top. This hole muſt be large enough to turn eaſy round the bottom of the ſpindle, at which place there muſt be a ſhoulder, to keep the wheel from touching the ſtand: at the top of the ſpindle put the ſmall wheel, and join it to a large one with a leader, in order to fire them both together.

## Port-Fires for Illuminations

Have their caſes made very thin of paper, and rolled on formers, from 2 to 5 8ths of an inch diameter, and are made from 2 to 6 inches long: they are pinched cloſe at one end, and left open at the other: when you fill them, put in but a little compoſition at a time, and ram it in lightly, ſo as not to break the caſe: 3 or 4 rounds of paper, with the laſt round paſted, will be ſtrong enough for theſe caſes.

## Common Port-Fires

Are intended purposely to fire the works, their fire being very slow, and the heat of the flame so intense, that, if applied to rockets, leaders, &c. it will fire them immediately. Port fires may be made of any length, but are seldom made more than 21 inches long: the interior diameter of port-fire moulds should be 10 10ths of an inch, and the diameter of the former, ½ an inch. The cases must be rolled wet with paste, and one end pinched, or folded down. The moulds should be made of brass, and to take in 2 pieces lengthwise: then, when the case is in the 2 sides, they are held together by brass rings, or hoops, which are made to fit over the outside. The bore of the mould must not be made quite through, so that there will be no occasion for a foot. Those port fires, when used, are held in copper sockets, fixed on the end of a long stick: these sockets are made like port crayons, only with a screw, instead of a ring.

## Cascades of Fire

Are made of any size; but one made according to the dimensions of that shewn in Plate 4. Fig. 43. will be large enough for 8 oz cases. Let the distance from A to B, be 3 feet; from B to C, 2 feet 6 inches: and from C D, 2 feet; and let the cross piece at A, be 4 feet long; then from each end of this piece, draw a line to D: then make the other cross pieces so long as to come within those lines. The top piece D, may be of any length so as to hold the cases, at a little distance from each other; all the cross pieces are fixed horizontally, and supported by brackets; the bottom cross piece should be about 1 foot 6 inches broad in the middle, the second 1 foot, the third 9 inches, and the top piece 4 inches: the cases may be made of any length, but must be filled with a brilliant charge. On the edges of the cross pieces must be nailed bits of wood, with a groove cut in each piece large enough

enough for a case to lie in. These bits of wood are fixed so as to incline downwards, and that the fire from one tier of cases may play over the other. All the cases being tied fast on, carry leaders from one to the other, and let there be a pipe hang from the mouth of one of the cases, covered at the end with a single paper, which you burn to fire the cascade.

## The Fire-Tree.

To make a fire-tree, as shewn by Fig. 44. you must first have a piece of wood 6 feet long, and 3 inches square; then at E, 9 inches from the top, make a hole in the front, and in each side; or, instead of holes, you may fix short pegs, to fit the inside of the cases. At F 9 inches from E, fix 3 more pegs; at G, 1 foot 9 inches from F, fix 3 pegs; at H, 9 inches from G, fix 3 pegs; at I, 9 inches from H, fix 3 pegs, inclining downwards; but all the other pegs must incline upwards, that the cases may have the same inclination as you see in the figure: then at top place a 4-inch mortar, loaded with stars, rains, or crackers. In the middle of this mortar place a case filled with any sort of charge, but let it be fired with the other cases: a brilliant charge will do for all the cases; but the mortar may be made of any diameter, and the tree of any size; and on it any number of cases, provided they are placed in the manner described.

## Chinese Fountains.

To make a Chinese fountain, you must have a perpendicular piece of wood 7 feet long, and 2 ½ inches square. 16 inches from the top, fix on the front a cross piece 1 inch thick, and 1 ½ broad, with the broad side up: below this, fix 3 more pieces, of the same width and thickness, at 16 inches from each other: let the bottom rail be 5 feet long, and the others of such a length as to allow the fire pumps to stand in the middle of the intervals of each other. The pyramid being thus made, fix in the holes made in the bottom rail, 5 fire pumps, at equal

equal diſtances; on the 2d rail place 4 pumps; on the 3d, 3; on the 4th, 2; and on the top of the poſt, 1: but place them all to incline a little forwards, that, when they throw out the ſtars, they may not ſtrike againſt the croſs rails. Having fixed your fire pumps, clothe them with leaders, ſo that they may all be fired together. See Fig. 45.

## Of Illuminated Globes with Horizontal Wheels.

The hoops for theſe globes may be made of wood, tin, or iron wire, about 2 feet diameter. For a ſingle globe take 2 hoops, and tie them together, one within the other, at right angles; then have a horizontal wheel made, whoſe diameter muſt be a little wider than the globe, and its nave 6 inches long, on the top of which the globe is fixed, ſo as to ſtand 3 or 4 inches from the wheel: on this wheel you may put any number of caſes, filled with what charge you like; but let 2 of them burn at a time: they may be placed horizontally, or to incline downwards, juſt as you chuſe. Now, when the wheel is clothed, fix on the hoops as many illuminations as will ſtand within 2 ½ inches of each other: theſe you faſten on the hoops with ſmall iron binding wire; and when they are all on, put on your pipes of communication, which muſt be ſo managed, as to light them all with the 2d or 3d caſe on the wheel. The ſpindle on which the globe is to run muſt go through the block of the wheel, up to the inſide of the top of the globe, where muſt be fixed a bit of braſs, or iron, with a hole in it to receive the point of the ſpindle, on which the whole weight of the wheel is to bear, as in Fig. 46, which repreſents a globe on its ſpindle. By this method may be made a crown, which is done by having the hoops bent in the form of a crown. Sometimes globes and crowns are ordered ſo as to ſtand ſtill, and the wheel only to turn round; but when you would have the globe or crown to ſtand ſtill, and the wheel

to

to run by itſelf, the block of the wheel muſt not be ſo long, nor the ſpindle any longer than to juſt raiſe the globe a little above the wheel; and the wheel caſes and illumination muſt begin together.

## Dodecaedron.

So called becauſe it nearly repreſents a twelve-ſided figure, and is made thus. Firſt have a ball turned out of ſome hard wood, 14 inches diameter: when done, divide its ſurface into 14 equal parts, from which bore holes 1 ½ inch diameter, perpendicular to the centre, ſo that they may all meet in the middle: then let there be turned in the inſide of each hole a female ſcrew; and to all the holes, but one, muſt be made a round ſpoke 5 feet long, with 4 inches of the ſcrew at one end, to fit the holes; then in the ſcrew end of all the ſpokes bore a hole, 5 inches up, which muſt be bored ſlanting, ſo as to come out at one ſide, a little above the ſcrew; from which cut a ſmall groove along the ſpoke, within 6 inches of the other end, where you make another hole through to the other ſide of the ſpoke: in this end fix a ſpindle, on which put a ſmall wheel, of 3 or 4 ſides, each ſide 6 or 7 inches long: theſe ſides muſt have grooves cut in them, large enough to receive a 2 or 4 oz. caſe: when theſe wheels are clothed, put them on the ſpindles, and at the end of each ſpindle put a nut to keep the wheel from falling off: the wheels being thus fixed, carry a pipe from the mouth of the firſt caſe on each wheel, thro' the hole in the ſide of the ſpoke, and from thence along the groove, and through the other hole, ſo as to hang out at the ſcrew end about an inch. The ſpokes being all prepared in this manner, you muſt have a poſt, on which you intend to fire the work, with an iron ſcrew in the top of it, to fit one of the holes in the ball: on this ſcrew fix the ball; then in the top hole of the ball put a little meal powder, and ſome looſe quick-match; then ſcrew in all the ſpokes, and in one ſide of the ball bore a hole, in which put a leader, and ſecure it at the end; and your work will be ready to be fired. By this leader the pow-
der

der and match in the centre is fired, which will light the match at the ends of the ſpokes all at once, whereby all the wheels will be lighted at once. There may be an addition to this piece, by fixing a ſmall globe on each wheel, or 1 on the top wheel only. A grey charge will be proper for the wheel caſes.

## The Yew Tree of Brilliant Fire

Is repreſented by Fig. 47. as it appears when burning. Firſt, let A be an upright piece of wood, 4 feet long, 2 inches broad, and 1 thick: at top of this piece, on the flat ſide, fix a hoop, 14 inches diameter; and round its edge and front place illuminations; and in the centre a 5-pointed ſtar; then at E, which is 1 ½ foot from the edge of the hoop, place 2 caſes of brilliant fire, 1 on each ſide: theſe caſes ſhould be 1 foot long each: below theſe fix 2 more caſes of the ſame ſize, and at ſuch a diſtance, that their mouths may almoſt meet them at top: then, cloſe to the ends of theſe caſes, fix 2 more of the ſame caſes; they muſt ſtand parallel to them at E. The caſes being thus fixed, clothe them with leaders; ſo that they, with the illuminations and ſtar at top, may all take fire together.

## Stars with Points for Regulated Pieces, &c.

Theſe ſtars are made of different ſizes, according to the work for which they are intended: they are made with caſes from 1 oz. to 1 lb. but in general with 4 oz. caſes, 4 or 5 inches long: the caſes muſt be rolled with paſte, and twice as thick of paper as a rocket of the ſame bore. Having rolled a caſe, pinch one end of it quite cloſe; then drive in ½ a diameter of clay, and when the caſe is dry, fill it with compoſition, 2 or 3 inches, to the length of the caſes, with which it is to burn: at top of the charge drive ſome clay; as the ends of theſe caſes are ſeldom punched, they would be liable to take fire. Having filled a caſe, divide the circumference of it at the pinched end cloſe to the clay into 5 equal parts; then bore

bore 5 holes with a gimblet, about the ſize of the neck of a common 4 oz. caſe, into the compoſition: from one hole to the other carry a quick-match, and ſecure it with paper: this paper muſt be put on in the manner of that on the ends of wheel caſes, ſo that the hollow part, which projects from the end of the caſe, may ſerve to receive a leader from any other work, to give fire to the points of the ſtar. Theſe ſtars may be made with any number of points.

## Fixed Sun with a Tranſparent Face.

To make a ſun of the beſt ſort there ſhould be 2 rows of caſes, as in Fig. 48, which will ſhew a double glory, and make the rays ſtrong and full. The frame, or ſun wheel, muſt be made thus: Have a circular flat nave made very ſtrong, 12 inches diameter: to this fix 6 ſtrong flat ſpokes, A, B, C, D, E, F. On the front of theſe fix a circular fell, 5 feet diameter; within which fix another fell, the length of one of the ſun caſes leſs in diameter; within this fix a 3d fell, whoſe diameter muſt be leſs than the 2d, by the length of 1 caſe and 1 3d. The wheel being made, divide the fells into ſo many equal parts as you would have caſes (which may be done from 24 to 44): at each diviſion fix a flat iron ſtaple: theſe ſtaples muſt be made to fit the caſes, to hold them faſt on the wheel: let the ſtaples be ſo placed, that one row of caſes may lie in the middle of the intervals of the other.

In the centre of the block of the ſun drive a ſpindle, on which put a ſmall hexagon wheel, whoſe caſes muſt be filled with the ſame charge as the caſes of the ſun: 2 caſes of this wheel muſt burn at a time, and begin with them on the fells. Having fixed on all the caſes, carry pipes of communication from one to the other, as you ſee in the figure, and from one ſide of the ſun to the wheel in the middle, and from thence to the other ſide of the ſun. Theſe leaders will hold the wheel ſteady while the ſun is fixing up, and will alſo be

be a ſure method of lighting both caſes of the wheel together. A ſun thus made is called a Brilliant ſun, becauſe the wood work is intirely covered with fire from the wheel in the middle, ſo that there appears nothing but ſparks of brilliant fire: but, if you would have a Tranſparent face in the centre, you muſt have one made of paſteboard, of any ſize. The method of making a face is, by cutting out the eyes, noſe, and mouth, for the ſparks of the wheel to appear through; but, inſtead of this face, you may have one painted on oiled paper, or Perſian ſilk, ſtrained tight on a hoop; which hoop muſt be ſupported by 3 or 4 pieces of wire at 6 inches diſtance from the wheel in the centre, ſo that the light of it may illuminate the face. By this method you may have, in the front of a ſun, VIVAT REX, cut in paſteboard, or Apollo painted on ſilk; but, for a ſmall collection, a ſun with a ſingle glory, and a wheel in front, will be moſt ſuitable. $\frac{1}{2}$ lb. caſes, filled 10 inches with compoſition, will be a good ſize for a ſun of 5 feet diameter; but, if larger, the caſes muſt be greater in proportion.

## Three Vertical Wheels illuminated, which turn on their own Naves upon a Horizontal Table.

A plan of this is ſhewn by Fig. 49. Let D be a deal table 3 feet 6 diameter: this table muſt be fixed horizontally on the top of a poſt; on this poſt muſt be a perpendicular iron ſpindle, which muſt come through the centre of the table: then let A, B, C, be 3 ſpokes joined to a triangular flat piece of wood, in the middle of which make a hole to fit eaſily over the ſpindle: let E, F, G, be pieces of wood, 4 or 5 inches long each, and 2 inches ſquare, fixed on the under ſides of the ſpokes; in theſe pieces make holes lengthwiſe to receive the thin part of the blocks of the wheels, which, when in, are prevented from coming out by a ſmall iron pin being run through the end of each. K, L, M, are 3 vertical octagon wheels,

wheels, 18 inches diameter each: the blocks of these wheels must be long enough for 3 or 4 inches to rest on the table; round which part drive a number of sharp points of wire, which must not project out of the blocks more than 1 16th of an inch: the use of these points is, that, when the blocks run round, they will stick in the table, and help the wheels forward: if the naves are made of strong wood, one inch will be enough for the diameter of the thin part, which should be made to turn easy in the holes in the pieces E, F, G. On the front of the wheels make 4 or 5 circles of strong wire, or flat hoops, and tie on them as many illuminations as they will hold at 2 inches from each other: instead of circles, you may make spiral lines, clothed with illuminations, at the same distance from each other as those on the hoops. When illuminations are fixed on a spiral line in the front of a wheel, they must be placed a little on the slant, the contrary way that the wheel runs: the cases for these wheels may be filled with any coloured charge, but must burn only one at a time.

The wheels being thus prepared, you must have a globe, crown, or spiral wheel, to put on the spindle in the middle of the table: this spindle should be just long enough to raise the wheel of the globe, crown, or spiral wheel, so high that its fire may play over the 3 vertical wheels: by this means their fires will not be confused, nor will the wheels receive any damage from the fire of each other. In clothing this work, let the leaders be so managed, that all the wheels may light together, and the illuminations after 2 cases of each wheel are burnt.

## Illuminated Chandelier.

Illuminated works are much admired by the Italians, and indeed are a great addition to a collection of works: in a grand exhibition an illuminated piece should be fired after every 2 or 3 wheels, or fixed pieces of common and brilliant fires; and likewise illuminated works may be made cheap, quick, and easy.

To

To make an illuminated chandelier, you muſt firſt have one made of thin wood. See Fig. 50. The chandelier being made, bore in the front of the branches, and in the body, and alſo in the crown at top, as many holes for illuminations as they will contain, at 3 inches diſtance from each other: in theſe holes put illuminations filled with white, blue, or brilliant charge. Having fixed in the port fires, clothe them with leaders, ſo that the chandelier and crown may light together. The ſmall circles on this figure repreſent the mouths of the illuminations, which muſt project ſtrait from the front.

## Illuminated Yew-Tree.

Firſt have a tree made of wood, ſuch as is ſhewn by Fig. 51. The middle piece, or ſtem, on which the branches are fixed, muſt be 8 feet 6 inches high: at the bottom of this piece draw a line, at right angles, 2 feet 6 inches long at each ſide; then from L, which is 1 foot 6 inches from the bottom, draw a line on each ſide to C and D: theſe lines will give the length of the 2 firſt branches. Then put on the 2 top branches parallel to them at bottom: let the length of each of theſe branches be 1 foot from the ſtem: from the ends of theſe 2 branches draw a line to C and D: then fix on 5 more branches at an = diſtance from each other, and their length will be determined by the lines A C and E D. When the branches are fixed, place illuminating port fires on the top of each, as many as you chuſe: behind the top of the ſtem faſten a gerbe, or white fountain, which muſt be fired at the beginning of the illuminations on the tree.

## Flaming Stars with Brilliant Wheels.

To make a flaming ſtar, you muſt firſt have made a circular piece of ſtrong wood about 1 inch thick and 2 feet diameter: round this block fix 8 points, 2 feet 6 inches long each; 4 of theſe points muſt be ſtraight, and 4 flaming: theſe points being joined on very ſtrong, and even

with the furface of the block, nail tin or pafteboard on their edges, from the block to the end of each, where they muft be joined: this tin muft project in front 8 inches, and be joined where they meet at the block; round the front of the block fix 4 pieces of thick iron wire, 8 inches long each, equally diftant from each other: this being done, cut a piece of pafteboard round, 2 feet diameter, and draw on it a ftar, as may be feen in Fig. 52. This ftar cut out, and on the back of it pafte oiled paper; then paint each point half red, and half yellow, lengthwife; but the body of the ftar muft be left open, wherein muft run a brilliant wheel, made thus: Have a light block turned 9 inches long; at each end of it fix 6 fpokes; at the end of each fpoke put a 2 oz. cafe of brilliant fire: the length of thefe cafes muft be in proportion to the wheel, and the diameter of the wheel when the cafes are on muft be a little lefs than the diameter of the body of the fmall ftar: the cafes on the fpokes in front muft have their mouths incline outwards, and them on the infide fpokes muft be placed fo as to form a vertical circle of fire. When you place your leaders, carry the firft pipe from the tail of 1 of the cafes in front to the mouth of 1 of the infide cafes, and from the tail of that to another in front, and fo on to all the cafes. Your wheel being made, put it on a fpindle, in the centre of the ftar; this fpindle muft have a fhoulder at bottom, to keep the wheel at a little diftance from the block. This wheel muft be kept on the fpindle by a nut at the end; having fixed on the wheel, faften the tranfparent ftar to the 4 pieces of wire: when you fire it, you will only fee a common horizontal wheel; but when the firft cafe is burnt out, it will fire one of the vertical cafes, which will fhew the tranfparent ftar, and fill the large flames and points with fire; then it will again appear like a common wheel, and fo on for 12 changes.

## Touch-Paper for Capping of Serpents, Crackers, &c.

Diſſolve, in ſpirits of wine or vinegar, a little ſaltpetre; then take ſome purple or blue paper, and wet it with this liquor, and when dry it will be fit for uſe; when you paſte this paper on any of your works, take care that the paſte does not touch that part which is to burn. The method of uſing this paper is by cutting it into ſlips, long enough to go once round the mouth of a ſerpent, cracker, &c. When you paſte on theſe ſlips, leave a little above the mouth of the caſe not paſted; then prime the caſe with meal powder, and twiſt the paper to a point.

## Projected Regulated Piece of Nine Mutations.

A regulated piece, if well executed, is as curious a work as any in fireworks: it conſiſts of fixed and moveable pieces on one ſpindle, repreſenting various figures, which take fire ſucceſſively one from another, without any aſſiſtance after lighting the firſt mutation; but, for the better explanation of this piece, I ſhall give a full deſcription of the method of communicating the fire from one mutation to the other, with a figure of each as they ſtand on the ſpindle. Regulated pieces are made of many kinds, and of any number of mutations, from 2 to 9, which is the greateſt number I ever knew a piece to conſiſt of, except one of my own ma ing, which was compoſed of 15 mutations, all different fires and figures: but, as an explanation of ſo large a piece would be difficult to comprehend, I ſhall omit it, leaving ſo many changes to thoſe who have made a great progreſs in this art, and only teach the manner of ma ing a piece of 9 mutations, as ſhewn in Plate V, Fig. 53. As it will be neceſſary that every mutation ſhould be ſeparately explained,

I ſhall firſt give the name of each, with the colour of fire, and ſize of the caſe belonging to it; after which proceed with the proportion of each mutation, with the nature of the ſpindle, and placing the leaders.

## Firſt Mutation

Is a hexagon vertical wheel, illuminated in front with ſmall port fires tied on the ſpokes; this wheel muſt be clothed with 2 oz. caſes, filled with black charge; the length of theſe caſes is determined by the ſize of the wheel, but muſt burn ſingly.

## Second Mutation

Is a fixed piece, called a Golden Glory, by reaſon of the caſes being filled with ſpur-fire; the caſes muſt ſtand perpendicular to the block on which they are fixed, ſo that, when burning, they may repreſent a glory of fire: this mutation is generally compoſed of 5 or 7 2-oz. caſes.

## Third Mutation

Is moveable, and is only an octagon vertical wheel, clothed with 4 oz. caſes, filled with brilliant charge; 2 of theſe caſes muſt burn at a time: in this wheel you may make changes of fire.

## Fourth Mutation

Is a fixed ſun of brilliant fire, conſiſting of 12 4-oz. caſes; the necks of theſe caſes muſt be a little larger than thoſe of 4 oz. wheel caſes: in this mutation may be made a change of fire, by filling the caſes half with brilliant charge, and half with grey.

## Fifth Mutation

Is a fixed piece, called the Porcupine's Quills; this piece conſiſts of 12 ſpokes, ſtanding perpendicular to the

the block in which they are fixed; on each of these ſpokes, near the end, muſt be placed a 4 oz. caſe of brilliant fire; all theſe caſes muſt incline either to the right or left, ſo that they may all play one way.

## Sixth Mutation

Is a ſtanding piece, called the Croſs Fire. This mutation conſiſts of 8 ſpokes fixed in a block; near the end of each of thoſe ſpokes muſt be tied 2 4-oz. caſes of white charge, one acroſs the other, ſo that the fires from the caſes on 1 ſpoke may interſect the fire from caſes on the other.

## Seventh Mutation

Is a fixed wheel, with 2 circular fells, on which are placed 16 8-ounce caſes of brilliant fire, in the form of a ſtar; this piece is called a Fixed Star of Wild-fire.

## Eighth Mutation.

This is a beautiful piece, called a Brilliant Star-piece: it conſiſts of 6 ſpokes, which are ſtrengthened by 2 fells of a hexagon form, at ſome diſtance from each other; at the end of each ſpoke, in the front is fixed a brilliant ſtar of 5 points; and on each ſide of every ſtar is placed a 4 oz. caſe of black or grey charge; theſe caſes muſt be placed with their mouths ſideways, ſo that their fires may croſs each other.

## Ninth Mutation

Is a wheel piece: this is compoſed of 6 long ſpokes, with a hexagon vertical wheel at the end of each; theſe wheels run on ſpindles in the front of the ſpokes; all the wheels are lighted together: 2 oz. caſes will do for theſe wheels, and may be filled with any coloured charge.

After having ſpoke of the ſeveral parts of the regulated piece, each by their proper names and colour of fire, I ſhall next proceed with the proportion of every mutation, with the method of conveying the fire from one to the other. and the diſtance they ſtand one from the other on the ſpindle,

## Firſt Mutation

Muſt be a hexagon vertical wheel, 14 inches diameter; on one ſide of the block. whoſe diameter is 2 ½ inches, is fixed a tin barrel, A, ſee Fig. 53, No. 1. this barrel muſt be a little leſs in diameter than the nave; let the length of the barrel and block be 6 inches. Having fixed the caſes on the wheel, carry a leader from the tail of the laſt caſe into the tin barrel through a hole made on purpoſe, 2 inches from the block; at the end of this leader let there be about 1 inch or 2 of looſe match; but take care to ſecure well the hole wherein the pipe is put, to prevent any ſparks falling in, which would light the ſecond mutation before its time, and confuſe the whole.

## Second Mutation

Is thus made, Have a nave turned 2 ½ inches diameter, and 3 long; then let ½ an inch of that end which faces the firſt wheel be turned ſo as to fit eaſy into the tin barrel of the firſt mutation, which muſt turn round it without touching; on the other end of the block fix a tin barrel, B, N°. 2, this barrel muſt be 6 inches long, and only ½ an inch of it to fit on the block. Round the nave fix 5 ſpokes, 1 ½ inch long each; the diameter of the ſpokes muſt be equal to a 2 oz. former; on theſe ſpokes put 5 7-inch 2-oz. caſes of ſpur fire, and carry leaders from the mouth of one to the other, that they may all light together; then from the mouth of 1 of the caſes, carry a leader through a hole bored ſlantways in the nave, from between the ſpokes, to the front of the block near the ſpindle hole: the end of this leader muſt project out of

of the hole into the barrel of the firſt mutation, ſo that when the pipe which comes from the end of the laſt caſe on the firſt wheel flaſhes, it may take fire, and light the 2d mutation. To communicate the fire to the 3d mutation, bore a hole near the bottom of one of the 5 caſes to the compoſition, and from thence carry a leader into a hole made in the middle of the barrel B; this hole muſt be covered with paſted paper.

## Third Mutation

May be either an octagon or hexagon wheel, 20 inches diameter; let the nave be 3 ¾ inches diameter, and 3 ½ in length; 1 ½ inch of the front of the nave muſt be made to fit in the barrel B. On the other end of the block fix a tin barrel, C, N°. 3. this barrel muſt be 6½ inches in length, one inch of which muſt fit over the block. The caſes of this wheel muſt burn 2 at a time; and from the mouths of the 2 firſt caſes carry a leader, through holes in the nave, into the barrel of the ſecond mutation, after the uſual manner; but beſides theſe leaders let there be a pipe go acroſs the wheel from one firſt caſe to the other; then from the tail of one of the laſt caſes carry a pipe into a hole in the middle of the barrel C: at the end of this pipe let there hang ſome looſe quick match.

## Fourth and Fifth Mutations.

I ſhall here ſpeak of thoſe 2 mutations under 1 head, as their naves are made of 1 piece, which from E to F is 14 inches; E, a block 4 inches diameter, with 10 or 12 ſhort ſpokes, on which are fixed 11 inch 8 oz. caſes: let the front of this block be made to fit eaſy in the barrel C, and clothe the caſes ſo that they may all light together; and let a pipe be carried through a hole in the block into the barrel C, in order to receive the fire from the leader brought from the laſt caſe on the wheel. G, the nave of the 5th mutation, whoſe diameter muſt be 4 ½ inches: in this nave fix 10 or 12 ſpokes 1 ½ foot in

 length

length each; these spokes must stand 7 inches distant from the spokes of the 4th mutation; and at the end of each spoke tie a 4 oz. case, as No 5. all these cases are to be lighted together, by a leader brought from the end of 1 of the cases on No. 4. Let F and H be of the same piece of wood as E and G, but as much thinner as possible, to make the work light.

## Sixth and Seventh Mutations.

The blocks of these 2 mutations are turned out of 1 piece of wood, whose length from F to P is 15 inches. L, a block 5 inches diameter, in which are fixed 8 spokes, each 2 foot 4 inches long; at the end of each spoke tie 2 4 oz. cases, as N°. 6. all these cases must be fired at the same time, by a pipe brought from the end of one of the cases on the 5th mutation. Let the distance between the spokes at L and those in the 5th mutation be 7 inches. M, the nave of the 7th mutation, whose diameter must be 5 ½ inches: in this nave fix 8 spokes, and on the front of them 2 circular fells, 1 of 4 feet 8 inches diameter, and 1 of 3 feet 11 diameter; on these fells tie 16 8-oz. or pound cases as in N°. 7. and carry leaders from one to the other, so that they may be all fired together. This mutation must be fired by a leader brought from the tail of one of the cases on the sixth mutation.

## Eighth and Ninth Mutations.

The blocks of these may be turned out of one piece, whose length from P to D must be 12 inches. O, the block of the 8th mutation, which must be 6 inches diameter, and in it fixed 6 spokes, each 3 feet in length, strengthened by an hexagon fell within 3 or 4 inches of the ends of the spokes; close to the end of each spoke, in the front, fix a five-pointed brilliant star; then 7 inches below each star, tie 2 10-inch 8-oz. cases, so that the upper ends of the cases may rest on the fells, and their ends on the spokes; each of these cases must be placed parallel to the opposite fell. See N°. 8. NNN, &c. are the cases, and kkk, &c. the stars.

The

The 9th mutation is thus made. Let D be a block 7 inches diameter; in this block muſt be ſcrewed 6 ſpokes, 6 feet long each, with holes and grooves for leaders, as thoſe in the dodecaedron; at the end of each ſpoke, in the front, fix a ſpindle for a hexagon vertical wheel, 10 inches diameter, as in N°. 9. When theſe wheels are on, carry a leader from each into the block, ſo that they may all meet; then lead a pipe from the end of 1 of the caſes of the 8th mutation, through a hole bored in the block D, to meet the leaders from the vertical wheels, ſo that they may all be fired together.

The ſpindles for large pieces are required to be made very ſtrong, and as exact as poſſible: for a piece of 9 mutations, let the ſpindle be at the large end 1 inch diameter, and continue that thickneſs as far as the 7th mutation, and from thence to the 5th; let its diameter be $\frac{3}{4}$ of an inch; from the fifth to the fourth, 5 8ths of an inch; from the fourth to the ſecond, $\frac{1}{2}$ an inch; and from the ſecond to the end, 3 8ths of an inch: at the ſmall end muſt be a nut to keep on the firſt wheel, and at the thick end muſt be a large nut, as ſhewn by the figure; ſo that the ſcrew part of the ſpindle being put through a poſt, and a nut ſcrewed on tight, the ſpindle will be held faſt and ſteady; but you are to obſerve, that that part of the ſpindle, on which the moveable pieces are to run, be made long enough for the wheels to run eaſy without ſticking; the fixed pieces being made on different blocks, the leaders muſt be joined, after they are fixed on the ſpindle. The beſt method of preventing the fixed mutations from moving on the ſpindle, is, to make that part of the ſpindle which goes through them ſquare; but as it would be difficult to make ſquare holes through ſuch long blocks as are ſometimes required, it will be beſt to make them thus: Bore a round hole a little larger than the diameter of the ſpindle, and at each end of the block over the hole, faſten a piece of braſs with a ſquare hole in it to fit the ſpindle.

To

## To make an Horizontal Wheel change to a Vertical Wheel with a Sun in Front.

The fudden change of this piece is very pleafing, and gives great furprife to thofe who are not acquainted with the contrivance. A wheel for this purpofe fhould be about 3 feet diameter, and its fell circular, on which tie 16 half-pound cafes filled with brilliant charge; 2 of thefe cafes muft burn at a time, and on each end of the nave muft be a tin barrel of the fame conftruction as thofe on the regulated piece; the wheel being completed, prepare the poft or ftand thus: firft have a ftand made of any height, about 3 or 4 inches fquare; then faw off from the top, a piece 2 feet long; this piece join again at the place where it was cut, with a hinge on one fide, fo that it may lift up and down in the front of the ftand, then fix on the top of the bottom part of the ftand, on each fide a bracket: thefe brackets muft project at right angles with the ftand, 1 foot from the front, for the fhort piece to reft on; but thefe brackets muft be placed a little above the joint of the poft, fo that when the upper ftand falls, it may lie between them at right angles with the bottom ftand, which may be done by fixing a piece of wood, 1 foot long, between the brackets, and even with the top of the bottom ftand; then, as the brackets rife above the bottom ftand, they will form a channel for the fhort poft to lie in, and keep it fteady without ftraining the hinge: on the fide of the fhort poft oppofite the hinge, nail a piece of wood, of fuch a length, that, when the poft is perpendicular, it may reach about 1 ½ foot down the long poft, to which being tied, it will hold the fhort ftand upright: the ftand being thus prepared, in the top of it fix a fpindle 10 inches long; on this fpindle put the wheel, then fix on a brilliant fun with a fingle glory; the diameter of this fun muft be 6 inches lefs than that of the wheel. When you fire this piece, light the wheel firft, and let it

run

run horizontally till 4 cafes are confumed; then from the end of the 4th cafe carry a leader into the tin barrel that turns over the end of the ftand; this leader muft be met by another brought through the top of the poft, from a cafe filled with a ftrong port-fire charge, and tied to the bottom poft, with its mouth facing the pack-thread which holds up the ftand, fo that when this cafe is lighted, it will burn the pack-thread, and let the wheel fall forward, by which means it will become vertical; then from the laft cafe of the wheel, carry a leader into the barrel next the fun, which will begin as foon as the wheel is burnt out.

## Grand Volute illuminated with a projected Wheel in Front.

Firft have 2 hoops made of ftrong iron wire, one of 6 feet diameter, and one of 4 feet 2 inches; thefe hoops muft be joined to fcrolls A, A, A, &c. as in Fig. 54. Thefe fcrolls muft be made of the fame fort of wire as the hoops: on thefe fcrolls tie, with iron binding wire, as many illuminating port-fires as they will hold, at 2 inches diftance: thefe port fires clothe with leaders, fo that they may all take fire together; then let C be a circular wheel of 4 fpokes, 3 feet 6 inches diameter, and on its fell tie as many 4 oz. cafes, head to tail, as will complete the circle, only allowing a fufficient diftance between the cafes, that the fire may pafs free, which may be done by cutting the upper part of the end of each cafe a little fhelving: on each fpoke fix a 4 oz. cafe about 3 inches from the fell of the wheel; thefe cafes are to burn one at a time, and the firft of them to begin with thofe on the fell, of which 4 are to burn at a time, fo that the wheel will laft no longer than ¼ of the cafes on the fell, which in number fhould be 16 or 20: on the front of the wheel form a fpiral line, with ftrong wire, on which tie port fires, placing them on a flant, with their mouths to face the fame way as the cafes on the wheel; all thefe port fires muft be fired with the 2d cafes of wheel. Let D, D, D, &c. be fpokes of wood, all made to fcrew into a block in the centre; each of thefe

fpokes

ſpokes may be in length about 4 feet 6 inches; in the top of each fix a ſpindle, and on each ſpindle put a ſpirali wheel of 8 ſpokes, ſuch as E, E, E, &c. The blocks of theſe wheels muſt have a hole at top for the centre caſes, and the ſpindle muſt have nuts ſcrewed on their ends; which nuts ſhould fit in the holes at top of the blocks, ſo ſo that all the wheels muſt be put on before you fix in the centre caſes: as ſome of theſe wheels by reaſon of their ſituation will not bear on the nut, it will be neceſſary to have ſmooth ſhoulders made on the ſpindles for the blocks to run on; the caſes of theſe wheels are to burn double, and the method of firing them is, by carrying a leader from each down the ſpokes into the block in the centre, as in the dodecaedron, but the centre caſe of each wheel muſt begin with the 2 laſt caſes as uſual. It is to be obſerved, that the large circular wheel in front muſt have a tin barrel on its block, into which a pipe muſt be carried from one of the ſecond caſes on the wheel; this pipe being met by another from the large block, in which the 8 ſpokes are ſcrewed, will fire all the ſpirali wheels and the illuminating port fires at the ſame time. The caſes of the projected wheel may be filled with a white charge, and thoſe of the ſpirali wheels, with a grey.

## Moon and Seven Stars.

Let Fig. 55. be a ſmooth circular board, 6 feet diameter; out of the middle of it cut a circular piece 12 or 14 inches diameter, and over the vacancy put white Perſian ſilk, on which paint a moon's face; then let I, I, I, &c. be ſtars each 4 or 5 inches diameter, cut out with 5 points, and covered with oiled ſilk: on the front of the large circular board, draw a 7-pointed ſtar, as large as the circle will allow; then on the lines which form this ſtar, bore holes, wherein fix pointed ſtars. When this piece is to be fired, it muſt be fixed upon the front of a poſt, on a ſpindle, with a wheel of brilliant fire behind the face of the moon; ſo that while the wheel burns, the moon and ſtars will appear tranſparent, and when the wheel has burnt out, they will diſappear,

appear, and the large ſtar in front, which is formed of pointed ſtars, will begin, being lighted by a pipe of communication from the laſt caſe of the vertical wheel, behind the moon; this pipe muſt be managed in the ſame manner as thoſe in regulated pieces.

## Double Cone Wheel Illuminated.

This piece is repreſented by Fig. 56. Let A be a ſtrong decagon wheel, 2 feet 6 inches diameter; then on each ſide of it fix a cone B and C; theſe cones are to conſiſt of a number of hoops, ſupported by 3 or 4 pieces of wood, in the manner of the ſpiral wheels: let the height of each cone be 3 feet 6 inches, and on all the hoops tie port fires horizontally, with their mouths outwards, and clothe the wheel with 8 ounce caſes, all to play horizontally, 2 at a time: the cones may be fired with the firſt or ſecond caſes. The ſpindle for this piece muſt go through both the cones, and riſe 3 feet above the point of the cone at top, ſo that its length will be 10 feet 4 inches from the top of the poſt H, in which it is fixed, allowing 4 inches for the thickneſs of the block of the wheel: the whole weight of the wheel and cones muſt bear on a ſhoulder in the ſpindle, on which the block of the wheel muſt turn: near the top of the ſpindle muſt be a hole in the front, into which ſcrew a ſmall ſpindle, after the cones are on; then on this ſmall ſpindle fix a ſun, D, compoſed of 16 nine-inch 4 oz. caſes, of brilliant fire; which caſes muſt not be placed on a fell, but only ſtuck into a block of 6 inches diameter: then in the front of this ſun muſt be a circular vertical wheel, 16 inches diameter; on the front of this wheel form with iron wire a ſpiral line, and clothe it with illuminations, after the uſual method. As this wheel is not to be fired till the cones are burnt out, the method of firing it is,—Let the hole in the block, at the top of the uppermoſt cone, be a little larger than the ſpindle which paſſes through it; then, from the firſt caſe of the vertical wheel before the ſun, carry a leader down the ſide of the ſpindle to the top of

of the block of the horizontal wheel, on which muſt be a tin barrel; then this leader, being met by another brought from the end of the laſt caſe of the horizontal wheel, will give fire to the vertical wheel, ſo ſoon as the cones are extinguiſhed; but the ſun, D, muſt not be fired, till the vertical wheel is quite burnt out.

## Fire-Pumps.

Caſes for fire-pumps are made as thoſe for tourbillons; only they are paſted, inſtead of being rolled dry. Having rolled and dried your caſes, fill them: firſt put in a little meal powder, and then a ſtar; on which ram lightly a ladle or 2 of compoſition, then a little meal powder, and on that a ſtar, then again compoſition, and ſo on till you have filled the caſe. Stars for fire-pumps ſhould not be round, but muſt be made either ſquare, or flat and circular, with a hole through the middle: the quantity of powder for throwing the ſtars muſt increaſe as you come near the top of the caſe; for, if much powder be put at the bottom, it will burſt the caſe. The ſtars muſt differ in ſize, in this manner: let the ſtar which you put in firſt, be about ¼ leſs than the bore of the caſe; but let the next ſtar be a little larger, and the 3d ſtar a little larger than the 2d, and ſo on: let them increaſe in diameter, till within 2 of the top of the caſe, which 2 muſt fit in tight. As the loading of fire-pumps is ſomewhat difficult, it will be neceſſary to make 2 or 3 trials, before you depend on their performance: when you fill a number of pumps, take care not to put in each an equal quantity of charge between the ſtars, ſo that when they are fired they may not throw up too many ſtars together. Caſes for fire-pumps ſhould be made very ſtrong, and rolled on 4 or 8 oz. formers, 10 or 12 inches long each.

Vertical

## Vertical Scroll Wheel.

This wheel may be made of any diameter, but muſt be conſtructed as in Fig. 57, to do which proceed thus: Have a block made of a moderate ſize, into which fix 4 flat ſpokes, and on them fix a flat circular fell of wood; round the front of this fell place port-fires; then on the front of the ſpokes form a ſcroll, either with a hoop or ſtrong iron wire; on this ſcroll tie caſes of brilliant fire, in proportion to the wheel, head to tail, as in the figure. When you fire this wheel, light the firſt caſe near the fell; then, as the caſes fire ſucceſſively, you will ſee the circle of fire gradually diminiſh; but whether the illuminations on the fell begin with the ſcroll, or not, is immaterial, that being left intirely to the maker.

N. B. This wheel may be put in the front of a regulated piece, or fired by itſelf, occaſionally.

## Pin-Wheels.

Firſt roll ſome paper pipes, about 14 inches long each: theſe pipes muſt not be made thick of paper, 2 or 3 rounds of elephant paper being ſufficient. When your pipes are thoroughly dried, you muſt have made a tin tube, 12 inches long, to fit eaſy into the pipes; at one end of this tube fix a ſmall conical cup, which done is called a funnel: then bend 1 end of 1 of the pipes, and put the funnel in at the other, as far as it will reach, and fill the cup with compoſition: then draw out the funnel by a little at a time, ſhaking it up and down; and it will fill the pipe as it comes out. Having filled ſome pipes, have made ſome ſmall blocks, about 1 inch diameter, and ½ inch thick: round 1 of theſe blocks wind and paſte a pipe, and to the end of this pipe join another; which muſt be done by twiſting the end of one pipe to a point, and putting it into the end of the other, with a little paſte: in this manner join 4 or 5 pipes, winding them one upon the other, ſo as to form a ſpiral line. Having wound on your pipes,

paſte

paſte 2 ſlips of paper acroſs them, to hold them together: beſides theſe ſlips of paper the pipes muſt be paſted together.

There is another method of making theſe wheels, called the French; which is, by winding on the pipes without paſte, and ſticking them together with ſealing-wax, at every half-turn; ſo that, when they are fired, the end will fall looſe every time the fire paſſes the wax; by which means the circle of fire will be conſiderably increaſed. The formers for theſe pipes are made from 1 ½ to 4 16ths of an inch diameter, and the compoſition for them as follows; meal powder 8 oz. ſaltpetre 2 oz. and ſulphur 1: among theſe ingredi nts may be mixed a little ſteel-filings, or the duſt of caſt iron: this compoſition ſhould be very dry, and not made too fine, or it will ſtick in the funnel. Theſe wheels may be fired on a large pin, and held in the hand with ſafety.

## Fire-Globes.

There are 2 ſorts of fire globes, one with projected caſes, the other with the caſes concealed thus: Have a globe made of wood, of any diameter you chuſe, and divide the ſurface of it into 14 equal parts, and at each diviſion bore a hole perpendicular to the centre: theſe holes muſt be in proportion to the caſes intended to be uſed: in every hole, except one, put a caſe filled with brilliant, or any other charge, and let the mouths of the caſes be even with the ſurface of the globe; then cut in the globe a groove, from the mouth of one caſe to the other, for leaders, which muſt be carried from caſe to caſe, ſo that they may all be fired together: this done, cover the globe with a ſingle paper, and paint it. Theſe globes may be uſed to ornament a building.

Fire-globes with projected caſes are made thus: Your globe being made with 14 holes bored in it as uſual, fix in every hole, except one, a caſe, and let each caſe project from the globe 2 thirds of its length; then clothe all the caſes with leaders, ſo that they may all take fire

at

at the ſame time. Fire-globes are ſupported by a pintle made to fit the hole in which there is no caſe.

## To thread and join Leaders, and place them on different Works.

Joining and placing Leaders is a very eſſential part of fire-works, as it is on the leaders that the performance of all complex works depends; for which reaſon I ſhall endeavour here to explain the method of conducting pipes of communication, in as plain a manner as poſſible. Your works being ready to be clothed, proceed thus: Cut your pipes of a ſufficient length to reach from one caſe to the other; then put in the quick-match, which muſt always be made to go in very eaſy: when the match is in, cut it off within about an inch of the end of the pipe, and let it project as much at the other end; then faſten the pipe to the mouth of each caſe with a pin, and put the looſe ends of the match into the mouths of the caſes, with a little meal powder: this done to all the caſes, paſte over the mouth of each 2 or 3 bits of paper. The preceding method is uſed for large caſes, and the following for ſmall, and for illuminations: Firſt thread a long pipe; then lay it on the tops of the caſes, and cut a bit off the under ſide, over the mouth of each caſe, ſo that the match may appear; then pin the pipe to every other caſe, but before you put on the pipes, put a little meal powder in the mouth of each caſe: if the caſes thus clothed are port fires on illuminated works, cover the mouth of each caſe with a ſingle paper; but, if they are choaked caſes, ſituated ſo that a number of ſparks from other works may fall on them before they are fired, ſecure them with 3 or 4 papers, which muſt be paſted on very ſmooth, that there may be no creaſes for the ſparks to lodge in, which oft ſet fire to the works before their time. Avoid, as much as poſſible, placing the leaders too near, or one acroſs the other ſo as to touch, as it may happen that the flaſh of one will fire the other; therefore, if your works ſhould be ſo formed, that the leaders muſt croſs or touch, be ſure

to make them very ſtrong, and ſecure at the joints, and at every opening.

When a great length of pipe is required, it muſt be made by joining ſeveral pipes in this manner: Having put on 1 length of match as many pipes as it will hold, paſte paper over every joint; but, if a ſtill greater length is required, more pipes muſt be joined, by cutting off about an inch of one ſide of each pipe near the end, and laying the quick-match together, and tying them faſt with ſmall twine; after which, cover the joining with paſted paper.

## Placing Fire-works to be exhibited, with the Order of Firing.

Nothing adds more to the appearance of fire-works, than the placing them properly; though the manner of placing them chiefly depends on the judgement of the maker. I ſhall give ſuch rules here, as have been generally obſerved; for example, whether your works are to be fired on a building, or on ſtands: If they are a double ſet, place one wheel of a ſort on each ſide of the building; and next to each of them, towards the centre, place a fixed piece, then wheels, and ſo on; leaving a ſufficient diſtance between them, for the fire to play from one without burning the other: Having fixed ſome of your works thus in front, place the reſt behind them, in the centre of their intervals: the largeſt piece, which is generally a regulated or tranſparent piece, muſt be placed in the centre of the building, and behind it a ſun, which muſt always ſtand above all the other works: a little before the building, or ſtands, place your large gerbes; and at the back of the works, fix your marron batteries, pots des aigrettes, pots des brins, pots des ſauciſſons, air ballóóns, and flights of rockets: the rocket ſtands may be fixed behind, or any where elſe, ſo as not to be in the way of the works.

Single

Single collections are fired on ſtands; which ſtands are made in the ſame manner as theodolite ſtands, only the top part muſt be long or ſhort occaſionally: theſe ſtands may be fixed up very ſoon without much trouble. Having given ſufficient inſtructions for placing of fireworks, I ſhall proceed with the manner of firing them.

## Order of Firing.

1. Two ſignal
2. Six ſky
   rockets
3. Two honorary
4. Four caduceus
5. vertical
   Two wheels illuminated
6. ſpiral
7. tranſparent ſtars
8. A line rocket of 5 changes
9. Four tourbillons
10. horizontal wheels
11. air balloons illuminated
12. Two Chineſe fountains
13. regulating pieces of 4 mutations each
14. pots des aigrettes
15. Three large gerbes
16. A flight of rockets
17. Two ballóón wheels
18. caſcades of brilliant fire
19. Twelve ſky rockets
20. Two illuminated yew trees
21. air balloons of ſerpents, and 2 compound
22. Four tourbillons
23. Two Fruiloni wheels
24. illuminated globes with horizontal wheels
25. One pot des ſauciſſons
26. Two plural wheels
27. Marron battery
28. Two chandeliers illuminated
29. Range of pots des brins



30. Twelve

30. Twelve ſky rockets
31. Two yew-trees of fire
32. Neſt of ſerpents
33. Two double cones illuminated
34. Regulating piece of ſeven mutations, viz.
    1. Vertical wheel illuminated
    2. Golden glory
    3. Octagon vertical wheel
    4. Porcupine's quills
    5. Croſs fires
    6 Star piece with brilliant rays
    7. Six vertical wheels
35. Brilliant ſun
36. Large flight of rockets.

When water-works are to be exhibited, divide them into ſeveral ſets, and fire one ſet after every fifth or ſixth change of land and air-works. Obſerve this rule in firing a double ſet of works; always to begin with ſky-rockets, then two moveable pieces; then two fixed pieces, and ſo on; ending with a large flight of rockets, or a marron battery: if a ſingle collection, fire a fixed piece after every wheel or two, and now and then ſome air and water-works.

## Fountain of Sky Rockets.

Plate 6th, Fig. 1. repreſents a fountain of 30 rockets. Let A be a perpendicular poſt, 16 feet high from the ground, and 4 inches ſquare. Let the rail, or croſs piece, C, be 1 foot 6 inches long, 3 inches broad, and 1 thick. The rail D, at bottom, muſt be 6 feet long, 1 foot broad, and 1 inch thick. F, and G, are the two ſides which ſerve to ſupply the rails D, E, H, I, C: theſe ſides are 1 foot broad at bottom, and cut in the front with a regular ſlope, to 3 inches at top; but their back edges muſt be parallel with the front of the pots A. The breadth of the rails E, H, I, will be determined by the breadth of the ſides: all the rails muſt be fixed at 2 feet diſtance

diſtance from each other, and at right angles with the pots. Having placed the rails thus, bore in the bottom rail 10 holes, at equal diſtances, large enough to receive the ſtick of a one-pound rocket; in the back edge of this rail cut a groove from one end to the other, fit to contain a quick-match; then cut a groove in the top of the rail, from the edge of each hole, into the groove in the back: in the ſame manner cut in the ſecond rail, E, 8 holes and grooves; in the third rail, H, 6 holes and grooves; in the fourth rail, I, 4 holes and grooves; and in the top rail, 2 holes and grooves. B, a rail with holes in it to guide the ends of the rocket ſticks: this rail muſt be fixed 6 feet from the rail D. The fountain frame being thus made, prepare your rockets thus: Tie round the mouth of each a piece of thin paper, large enough to go twice round, and to project about an inch and ½ from the mouth of the rocket, which muſt be rubbed with wet meal-powder; in the mouth of each rocket put a leader, which ſecure well with the paper that projects from the mouth of the caſe: theſe leaders muſt be carried into the grooves in the back of the rails, in which lay a quick-match from one end to the other, and cover it with paſted paper: holes muſt be made in the rail D, to receive the ends of the ſticks of the rockets, in the rail E, and ſo on to the fourth rail; ſo that the ſticks of the rockets at top will go through all the rails. The rockets being ſo prepared, fix a gerbe, or white flower pot, on each rail, before the poſt, with their mouths inclining a little forwards: theſe gerbes muſt be lighted all at once. Behind or before each gerbe, fix a caſe of brilliant or ſlow fire: theſe caſes muſt be filled ſo that they may burn out one after the other, to regulate the fountain, which may be done by carrying a leader, from the end of each ſlow or brilliant fire, into the groove in the back of each rail. Different ſized rockets may be uſed in theſe fountains; but it will be beſt to fill the heads of the rockets on each rail with different ſorts of things, in this manner; thoſe at top with crackers, the next with rains, the third with

 ſerpents,

ſerpents, the fourth with tailed ſtars, and the laſt flight with common or brilliant ſtars.

## Palm-Tree.

This piece, though made of common fires, and of a ſimple conſtruction, has a very pleaſing effect; owing to the fires interſecting ſo oft, that they reſemble the branches of trees. Fig. 2d. Let A be a perpendicular poſt, of any thickneſs, ſo that it is ſufficiently ſtrong to hold the caſes: let the diſtance from B to C be 2 feet 6 inches, and from C to D 2 feet 6 inches; and let the length of each croſs piece be 2 feet, on each end of each fix a five-pointed ſtar; then fix on pegs made on purpoſe, 12 inch half-pound caſes of brilliant fire, as in the figure. All the caſes and ſtars muſt be fired at once. This piece ſhould be fixed high from the ground.

## Illuminated Pyramid, with Archimedian Screws, a Globe and Vertical Sun,

May be made of any ſize: one made according to the dimenſions of Fig. 3d, will be a good proportion, whoſe height is 21 feet; from C to D, 6 feet; from E to F, 9 feet: the ſpace between the rails muſt be 6 inches, and the rails as thin as poſſible: in all the rails ſtick port-fires at 4 inches diſtance. The Archimedian ſcrews, G, K, are nothing more than double ſpiral wheels, with the caſes placed on their wheels horizontally, inſtead of obliquely. The vertical ſun, I, need not conſiſt of more than 12 rays, to form a ſingle glory. The globe at top muſt be made in proportion to the pyramid, which being prepared according to the preceding directions, place your leaders ſo that all the illuminating port-fires, ſcrews, globe, and ſun, may take fire together. The pyramid muſt be ſupported by the 2 ſides, and by a ſupport brought from a pole, which muſt be placed 2 feet from the back of the pyramid, that the wheels may run free.

## Rofe-Piece and Sun.

A rofe-piece may be ufed for a mutation of a regulated piece, or fired by itfelf: it makes the beft appearance when made large; if its exterior diameter be 6 feet, it will be a good fize. Fig. 4. fhews the manner it appears in, before it is fired. Let the exterior fell be made of wood, and fupported by 4 wooden fpokes: all the other parts, on which the illuminations are fixed, muft be made of ftrong iron wire: on the exterior fell place as many ½lb. cafes of brilliant charge as you think proper, but the more the better; for the nearer the cafes are placed, the ftronger will be the rays of the fun: the illuminations fhould be placed within 3 inches of each other; they muft be all fired together, and burn fome time before the fun is lighted; which may be done by carrying a leader from the middle of one of the illuminations, to the mouth of one of the fun cafes.

## Tranfparent Stars with Illuminated Rays,

Plate 7, Fig. 5th, reprefents an illuminated ftar. Let the diameter from A to B be 2 feet, and from C to D, 7 feet. Firft make a ftrong circular back or body of the ftar, 2 feet diameter, to which you fix the illuminated rays: in the centre of the front of the body fix a fpindle, on which put a double triangular wheel, 6 inches diameter, clothed with 2 ounce cafes of brilliant charge: the cafes on this wheel muft burn but 1 at time. Round the edge of the body nail a hoop made of thin wood or tin: this hoop muft project in front 6 or 7 inches: in this hoop cut 3 or 4 holes to let out the fmoke from the wheel. The ftar and garter may be cut out of ftrong pafte-board, or tin, made in this manner: cut a round piece of pafteboard, or tin, 2 feet diameter, on which draw a ftar, and cut it out; then over the vacancy pafte Perfian filk; paint the letters yellow; 4 of the rays yellow, and 4 red; the crofs in the middle may be painted half red, and half yellow, or yellow and blue. This

 tranfparent

tranſparent ſtar muſt be faſtened to the wooden hoop by a ſcrew, to take off and on: the illuminated rays are made of thin wood, with tin ſockets fixed on their ſides within 4 inches of each other; in theſe ſockets ſtick illuminating port-fires; behind the point of each ray fix a half-pound caſe of grey, black, or Chineſe fire.

N. B. The illuminated rays to be lighted at the ſame time as the triangular wheel, or after it is burnt out; which may be done by a tin barrel being fixed to the wheel, after the manner of thoſe in the regulated pieces. Into this barrel carry a leader from the illuminated rays, through the back of the ſtar; which leader muſt be met by another, brought from the tail of the laſt caſe on the wheel.

## Tranſparent Table Star illuminated.

Fig. 6th repreſents a table ſtar, whoſe diameter, from E to F, is 12 feet; and from E to I, 4. This proportion, obſerved on each ſide, will make the centre frame 4 feet ſquare: in this ſquare fix a tranſparent ſtar, as in the figure. This ſtar may be painted blue, and its rays made as thoſe of the flaming ſtars deſcribed in page 113. The wheel for this ſtar may be compoſed of different coloured fires, with a change or 2 of ſlow fire: the wheels a, a, a, a, may be clothed with any number of caſes, ſo that the ſtar wheel conſiſts of the ſame: the illuminating portfires, which muſt be placed very near each other on the frames, muſt be ſo managed as to burn as long as the wheels, and lighted at the time.

## The Regulated Illuminated Spirali Piece, with a projected Star Wheel illuminated.

This piece is repreſented by Fig. 7. and is thus made. Have a block made 8 inches diameter; in this block ſcrew 6 iron ſpokes, which muſt ſerve for ſpindles for the ſpiral wheels; theſe wheels are made as uſual, each 1 foot 6 diameter,

6 diameter, and 3 feet in height: the ſpindles muſt be long enough to keep the wheels 4 or 5 inches from one another: at the end of each ſpindle muſt be a ſcrew nut, on which the wheels that hang downwards will run; and on the ſpindles which ſtand upwards muſt be a ſhoulder, for the blocks of the wheels to run on.

The projected ſtar-wheel muſt turn on the ſame ſpindle on which the large block is fixed: this ſpindle muſt be long enough to allow the ſtar-wheel to project a little before the ſpiral wheels: the exterior diameter of the ſtar-wheel muſt be 3 feet 5. On this wheel fix 3 circles of iron wire, and on them port-fires; on the block place a tranſparent ſtar, or a large 5-pointed brilliant ſtar. The caſes on this wheel may burn 4 at once, as it will contain near twice the number of one of the ſpiral wheels: the caſes on the ſpiral wheels muſt be placed parallel to their fells, and burn 2 at a time.

## A New Figure-Piece illuminated with Five-Pointed Stars.

The conſtruction of this piece is very eaſy, as ſhewn by Fig. 8, whoſe diameter from B to C is 8 feet, and from D to E 2 feet: the vertical wheel in the centre muſt be 1 foot diameter, and conſiſt of 6 four-ounce caſes of different coloured charge, which caſes muſt burn double: on the frames fix 5-pointed brilliant or blue ſtars, rammed 4 inches with compoſition: let the ſpace between each ſtar be 8 inches; at each point fix a gerbe, or caſe of Chineſe fire. When to be fired, let the gerbes, ſtars, and wheel, be lighted at the ſame time.

## The Star-Wheel Illuminated.

This beautiful new-invented piece is ſhewn in Plate 8, Fig. 9. its exterior fell is made of wood, 3 feet 6, or 4 feet diameter: within this fell, form with iron wire 3 circles, one leſs than the other, ſo that the diameter of the leaſt may

may be about 10 inches: place the port-fires on theſe fells with their mouths inclining outwards, and the port-fires on the points of the ſtar with their mouths projecting in front: let the exterior fell be clothed with 4-ounce caſes of grey charge: theſe caſes muſt burn 4 at a time, and be lighted at the ſame time as the illuminations.

## Pyramid of Flower-Pots.

Fig. 10. repreſents this curious piece, which muſt be made thus. Let the diſtance from A to B be 6 feet, and from one rail to the other 2: on the bottom rail fix 5 paper mortars, each 3½ inches diameter: theſe mortars load with ſerpents, crackers, ſtars, &c.

In the centre of each mortar fix a caſe of ſpur-fire: on the ſecond rail fix 4 mortars, ſo as to ſtand exactly in the middle of the intervals of them on the bottom rail; on the third rail place 3 mortars; on the fourth, 2; and on the top of the poſts, 1: the bottom rail muſt be 6 feet long: all the mortars muſt incline a little forwards, that they may eaſily diſcharge; and the ſpur-fires rammed exactly alike, that the mortars may all be fired at the ſame time. Having prepared your pyramid according to the preceding directions, carry pipes of communication from one ſpur-fire to the other.

## The illuminated Regulating Piece.

Fig. 11. repreſents one half of this piece. A, A, A, A, are flat wooden ſpokes, each 5 feet long; and at the end of each place a vertical wheel, 10 inches diameter, clothed with 6 4-ounce caſes of brilliant fire: theſe caſes muſt burn but 1 at a time: on 2 of the ſpokes of each wheel place 2 port-fires, which muſt be lighted with the firſt caſe of the wheel; on each ſpoke A, A, &c. behind the wheels, place 6 caſes of the ſame ſize as them on the wheels: theſe caſes muſt be tied acroſs the ſpokes with their mouths all one way, and be made to take fire ſucceſſively one after the other, ſo that they may aſſiſt the whole pieces to turn round,

The

The diameter of the wheel B muſt be 2 feet 6, and its fell made of wood, which muſt be fixed to the large ſpokes: on this wheel place 24 caſes of the ſame ſort as them on the ſmall wheels; theſe caſes muſt burn 4 at a time: in this wheel make 3 circles with iron wire, and on them place illuminating port-fires, as in the figure: the ſtar points on the large ſpokes may be made of thin aſh-hoops; the diameter of theſe points cloſe to the centre wheel muſt be 11 inches: on theſe points place port-fires, at 3 ½ inches diſtance one from the other.

Fig. 12. repreſents the blocks of this piece. The diameters of theſe blocks, at A and B, muſt be 8 inches; and C and D, 4 ½ inches: the length of each of theſe blocks muſt be 6 inches: at the ſmall ends of theſe blocks fix an iron wheel 5 inches diameter, which wheels muſt have teeth, to turn the wheel E: this wheel is fixed on a ſmall ſpindle ſcrewed into the large ſpindle, which goes through the two blocks, and on which they run.

Suppoſing Fig. 11. to be on the block A, in Fig. 12, and to turn to the right, and another piece of the ſame conſtruction on the block B, with its fires placed ſo as to turn it to the left; you will find them move very true and faſt, by the help of the 3 iron wheels, which ſerve to regulate their motions, as well as to aſſiſt them in turning: let the iron circles in the front of the great wheels be of different diameters, ſo that when fired there may appear 6 circles. When this piece is fired, all the wheels and illuminations muſt be lighted at one time.

## To fix a Sky-Rocket with its Stick on the Top of another.

Rockets thus managed make a pretty appearance, by reaſon of a freſh tail being ſeen when the ſecond rocket takes fire, which will mount to a great height. The method of preparing theſe rockets is thus: Having filled a two-pounder, which muſt be filled only half a diameter above the piercer, and in its head not more than 10 or 12 ſtars; the

the ſtick of this rocket muſt be made a little thicker than common, and when made, cut it in half the flat way, and in each half make a groove, ſo that, when the 2 halves are joined, the hollow made by the grooves may be large enough to hold the ſtick of a half-pound rocket; which rocket make and head as uſual; the ſtick of this rocket put into the hollow of the large one, ſo far that the mouth of the rocket may reſt on the head of the two-pounder; from whoſe head carry a leader into the mouth of the ſmall rocket; which being done, your rockets will be ready for firing.

## A New Method of Placing Leaders.

The placing leaders on ſmall caſes, or illuminations, is a much quicker, ſtronger, and more expeditious way than that of uſing pins; which method has been practiſed till lately. Your port-fires being filled within about 3 8ths of an inch of the top, bore with an awl a hole thro' each ſide of the caſe, cloſe to the compoſition; then fill the mouths of the caſes with meal powder wetted with ſpirit of wine: when you have thus prepared your caſes, fix them on your works; then take an empty leader, and lay it on the mouths of as many caſes as it will reach; then, with your finger nail, mark the leader exactly in the middle of the mouth of each caſe; then at each mark, with a pair of ſciſſars, cut a bit out of the pipe, ſo that, when you put in the quick-match, it may be ſeen. This done, lay the leader on the caſes again, with that ſide on which the match is ſeen downwards; then take ſome ſmall twine, and put it through the holes in the mouths of the caſes, and tie on the leader: do this to every caſe, and cover them with ſingle paſted paper. By making uſe of this method your works may be made very clean, there being no occaſion to put dry meal powder in the mouths of the caſes, which always ſoils the works, and prevents the paſte from ſticking.

Here

Here I have taught the method of rolling, pinching, and filling all ſorts of caſes; the manner of pulverizing, mixing, and preparing, all compoſitions uſed in artificial fire-works; alſo the method of placing leaders, clothing wheels, fixed pieces, &c. in ſo plain a manner, that all fire-works may be made without any further inſtructions. A variety of pyrotechnical repreſentations only depends on the genius of the maker, by fixing different caſes and fires on works of various forms, of which there are many more.

But as thoſe I have given are the principal, I ſhall conclude with Mr. Muller's Laboratory and a few of his Mines; which are all that was wanting to complete this work.

Mr.

## Mr. MULLER on LABORATORY WORKS.

MY design is not to give here any more than what is just necessary for the young Artillerist to know in the course of his duty, referring that part which regards the Fire-works made for Rejoicing to the excellent Treatise on Artificial Fireworks, wrote by *Robert Jones*, who gives all that can be said on that subject, and has himself practised every part of it.

### Grapeshot.

The number of shot in a grape varies according to the service or size of the guns: in sea-service 9 is always the number; but by land it is increased to any number or size; from an ounce and a quarter in weight, to 3 or 4 pounds. It has not been determined, what number or size answers best in practice; which I think should be tried: for it is well known, that they oft scatter so much, that only a small number take place. It would not be a useless experiment, to try at what distance they would do most execution, and what is the best charge of powder. In sea-service, the bottoms and pins are made of iron, whereas those used by land are of wood: for what reason this distinction is made, I cannot tell, unless that these iron bottoms are supposed to destroy the riggings of ships more than the wooden.

To make grape-shot, a bag of coarse cloth is made just to hold the bottom which is put into it; then as many shot as the grape is to contain; and with a strong packthread they are quilted to keep the shot from moving, and when they are finished are put into boxes for carriage. When the shot are small, they are put into tin boxes that fit the bore of the gun. Leaden bullets are likewise used in

in the ſame manner. It muſt be obſerved, that whatever number or ſizes of the ſhots are uſed, they muſt weigh with their bottoms and pins nearly as much as the ſhot of the piece.

## Cartridges.

The loading and firing guns with cartridges is done much ſooner, and leſs liable to accidents, than with looſe powder. They are made of various ſubſtances, ſuch as paper, flannel, parchment, and bladders. When they are made of paper, the bottoms remain in the piece, and accumulate ſo much, that the priming cannot reach the powder; and therefore they muſt be drawn from time to time, which retards the ſervice. They have another inconveniency, which is, they retain the fire; and, if particular care is not taken in ſpunging the piece, they will ſet fire to the next cartridge, and the gunner that puts it into the piece will be in danger of loſing a hand or arm, as has ſometimes happened. When they are made of parchment or bladders, the fire ſhrivels them up, whereby they enter into the vent, and become ſo hard, that the priming iron cannot remove them ſo as to clear the vent. Nothing has been found hitherto to anſwer better than flannel, and is the only thing uſed at preſent, becauſe it does not keep fire, and therefore not liable to accidents in the loading; but as the duſt of powder paſſes through them, a parchment cap is made to cover them, which is taken off before this is put into the piece.

The beſt way of making flannel cartridges is, in my opinion, to boil the flannel in ſize; this will prevent the duſt of the powder from paſſing through them, and renders them ſtiff, and more manageable; for without this precaution they are ſo pliable, that when they are large, and contain much powder, they are very inconvenient in putting them into the piece. The Saxon, who introduced our preſent light field pieces, had a particular method of preparing cartridges, which was ſuch, that when laid into the fire they would not burn; and yet, by dipping them

into

into water before they were put into the piece, would take fire as quick as powder; but how he did it, nobody could tell; for he would not part with his ſecret.

In quick firing the ſhot is fixed to the cartridge by means of a wooden bottom, hollowed on one ſide ſo as to receive nearly half the ſhot, which is faſtened to it by two ſmall ſlips of tin croſſing over the ſhot, and nailed to the bottom; and the cartridge is tied to the other end of this bottom. They are fixed likewiſe in the ſame manner to the bottoms of the grapeſhot, which are uſed in field pieces.

## Portfires.

Portfires are uſed ſometimes inſtead of matches, to ſet fire to powder or compoſitions; and are diſtinguiſhed into wet and dry. The compoſition of wet portfires is, ſaltpetre 4, ſulphur 1, and mealed powder 4; when the compoſition is well mixed and ſieved, it is to be moiſtened with a little linſeed oil, and well rubbed with the hands till all the oil is well mixed with the compoſition. The compoſition of dry portfire is, ſaltpetre 4, ſulphur 1, mealed powder 2, and antimony 1. Theſe compoſitions are drove into ſmall paper caſes, and ſo kept till uſed.

## Quickmatch

Is made with three cotton ſtrands drawn into length, and put into a kettle covered with white wine vinegar, and a quantity of ſaltpetre and mealed powder, and boiled till well mixed. Others put only ſaltpetre into the water. After that, it is taken out hot, and laid in a trough where ſome mealed powder, moiſtened with ſpirits of wine, is thoroughly wrought into the cotton, by rolling it backwards and forwards with the hands: when this is done, they are taken out ſeparately, and drawn through mealed powder, then hung upon a line till dry.

Tubes

## Tubes uſed in quick Firing.

Theſe tubes are here made of tin: their diameter is two tenths of an inch, to enter into the vent of the piece; about 5 or 6 inches long, with a cap above, and cut ſlanting below in the form of a pen; and the point is ſtrengthened with ſome ſolder, that it may pierce the cartridge. Through this tube is drawn a quickmatch, and the cap is filled with mealed powder moiſtened with ſpirit of wine. To prevent the mealed powder from falling out by carriage, a cap of paper is tied over it, which is taken off when uſed; but latterly this cap is made of flannel ſteeped in ſpirits of wine, with ſaltpetre diſſolved in it; there is no occaſion to take it off, ſince it takes fire as quick as looſe powder.

An objection is made againſt theſe tubes, which is, that the tin is apt to ſpoil the quickmatch when they are kept for ſome time; and it is imagined, that ſalt water would ſoon corrode them, therefore not proper to be uſed on board of ſhips; this however has not been tried. The French uſe a ſmall reed, to which is fixed a wooden cap about two inches long, filled with mealed powder moiſtened with ſpirit of wine: a ſmall hole is made through them the ſize of a needle, through which the fire darts with great violence, and gives fire to the cartridge, which muſt be pierced with the priming iron. Theſe tubes may be kept a great while without being ſpoiled; but the piercing the cartridge retards the quickneſs of firing. The forementioned Saxon made his of copper, tapering towards the end, ſo as to enter the vent about half an inch, which is made ſo far in the ſame form, and the reſt very narrow: they are filled in the ſame manner as the French, and when fired, the flame darted through the cartridge without being pierced.

## Fuzes for Shells and Hand-Grenades.

The compoſition for fuzes is ſaltpetre 3, ſulphur 1, and mealed powder 3, 4, and ſometimes 5, according as required to burn quicker. Fuzes are chiefly made of very dry beech wood, and ſometimes of hornbeam taken near the root; the upper part of that wood ſplits very eaſily. They are turned rough, and bored at firſt, and then kept for ſeveral years in a dry place: the diameter of the hole is about a quarter of an inch, a little more or leſs is of no conſequence; the hole does not go quite through, leaving about a quarter of an inch at the bottom; and the head is made hollow in the form of a bowl. The compoſition is drove in with an iron driver, whoſe ends are capped with copper to prevent the compoſition from taking fire; and equally hard as poſſible; the laſt ſhovel-full being all mealed powder, and two ſtrands of quickmatch laid acroſs each other being drove in with it, the ends of which are folded up into the bowl, and a cap of parchment tied over it till uſed. Obſerve, that, when ſhells are to be thrown at a ſmall diſtance, the compoſition ſhould be made quicker than when they are to be thrown at a greater; for, by cutting them ſo as to burn but a ſhort time, they might not be long enough to be well fixed into the ſhell, by which the blaſt of the powder in the chamber would blow them out, without the ſhell being able to burſt. It muſt likewiſe be obſerved, that the cuſtom of fixing the ſhells at home is very bad, ſince it is not known how long they ſhould burn; and if they do not burſt as ſoon as they fall, the execution is but trifling. Another diſadvantage attends this practice; when they are carried into a hot climate the wood ſhrinks, though ever ſo dry before; and the fuzes looſen ſo much, that they fall out in the flight of the ſhell before it falls to the ground.

When the fuzes are to be drove, the lower end is cut off in a ſlope, ſo as the compoſition may give fire to the powder; and they muſt have ſuch a length, as to burſt nearly as ſoon as the ſhell touches the ground. When the

the diſtance of the battery from the object is known, the time of the ſhell's flight may be computed nearly; which being known, the fuze may be cut accordingly, by burning 2 or 3, and making uſe of a watch, or a ſtring by way of a pendulum.

Before ſhells are loaded, they muſt be well ſearched within and without by means of a copper grater, to ſee if there are no holes or cavities in them; after that put them into a tub of water, to cover them, with an empty fuze drove into them; and the mouth of a bellows, being introduced into the fuze, and worked, will cauſe bubbles in the water, if there are any holes in the ſhell; but if no bubbles appear, it is a ſign the ſhell is ſound and fit for ſervice.

When loaded, care muſt be taken that they are very dry within; and if the ſpike which ſupports the corp when they are caſt, and which remains in them, is not beat down, it muſt be done then, otherwiſe it would ſplit the fuze. Then the powder is put into it with a funnel, and not quite filled, that the fuze may have room to enter, which fuze is preſſed in at firſt by the hand as far as it will go, and then drove with a mallet as hard as poſſible, taking care not to ſplit it; for if the leaſt crack was in it, the compoſition would give fire to the powder, and the ſhell burſt either in the mortar or the air, and do no execution.

It is a query how much powder is to be put into a ſhell, ſo as to make it burſt in moſt pieces. It is agreed by moſt officers that they ſhould not be quite filled; one that has taken moſt pains to find it out, is of opinion that they ſhould be filled within one third part of what they can hold.

Lieutenant Pirle, a very ingenious mechanic, loſt in the Dodington ſome years ago going to the Eaſt-Indies, had found out a method, ſo that as ſoon as the ſhell touched the ground it burſted; but being too modeſt a man, had not the aſſurance to propoſe it to the maſter general of the ordnance, whereby the world was deprived of a moſt uſeful invention.

If the fuzes are to be kept for some time after they are drove, the top must be covered with a mixture of pitch 2, rosin 1, and bees wax 3, whereby no air can come to the composition; and it will keep as long as you please.

## Carcasses.

None but round carcasses are used at present, the flight of the oblong are so uncertain, that they are quite laid aside. The composition is pitch 2, saltpetre 4, sulphur 1, and corned powder 3. When the pitch is melted, the pot is taken off, and the ingredients well mixed put in; then the carcass is filled with as much as can be pressed in.

## Light Balls to discover the Enemy's Works.

There are various sorts described. Some made of tow dipped into a composition of sulphur, pitch, rosin, and turpentine; and worked up into a ball. Others take a ball of stone or iron, which is covered with several coats of composition, much like that before mentioned, till of a proper size; the last coat is to be of grained powder. But the best sort, in my opinion, is to make a shell of paper the size of the mortar, and to fill it with a composition of an equal quantity of sulphur, pitch, rosin, and mealed powder; which being well mixed, and put in warm, will give a clear fire, and burn a considerable time.

There are many more things used in the defence of a breach; such as sacks filled with powder, bottles, barrels, &c. but as the chief intent of all these is to set fire, and blow up the assailants, and which every military gentleman may easily execute, we shall say no more here about them; our design being to instruct the young artillerist in the essential parts of his business; and to make him master of these matters, he must work in the laboratory; for practice is the best master.

Fireship,

## Fireſhip, how to prepare it.

From the bulk-head at the forecaſtle to a bulkhead to be raiſed behind the main chains, on each ſide and acroſs the ſhip at the bulkheads, is fixed, cloſe to the ſhip ſides, a double row of troughs, 2 feet diſtance from each other, with croſs troughs quite round, at about 2 ½ feet diſtance; which are mortiſed into the others. The croſs troughs lead to the ſides of the ſhip, to the barrels and to the port-holes, to give fire both to the barrels and the chambers, to blow open the ports; and the ſide-troughs ſerve to communicate the fire all along the ſhip and the croſs troughs.

The timbers of which the troughs are made are about 5 inches ſquare; the depth of the troughs half their thickneſs, ſupported by croſs pieces at every 2 or 3 yards, nailed to the timbers of the ſhip, and to the wood work which incloſes the fore and main maſts, and takes in an oblong in the middle of the deck, extending to the outſide of both the maſts and in breadth is near one half of the deck; and is what makes the carpenter's room for his ſtores. The decks and troughs are all well paved with melted roſin.

On each ſide of the ſhip are cut out 6 ſmall port-holes, in ſize about 15 by 18 inches, the ports opening downwards, are cloſe caulked up: againſt each port is fixed an iron chamber, which, at the time of firing the ſhip, blows open the ports and lets out the fire. At the main and fore chains on each ſide is a wooden funnel fixed over a fire barrel, and comes through a ſcuttle in the deck up to the ſhrouds to give fire to them; and between them are cut two ſcuttles on each ſide the ſhip, which alſo ſerve to let out the fire. Both funnels and ſcuttles muſt be ſtopt with plugs, and have ſail-cloth or canvas nailed cloſe over them, to prevent any accident happening that way by fire to the combuſtibles below.

The port-hole, funnels, and ſcuttles, not only ſerve to give the fire a free paſſage to the outſide and upper

parts of the ſhip, and its rigging, but alſo for the inward air, otherwiſe confined, to expand itſelf, and puſh through thoſe holes at the time of the combuſtibles being on fire, and prevent the blowing up the decks, which otherwiſe muſt of courſe happen from ſuch a ſudden and violent rarefaction of the air as will then be produced.

In the bulkhead behind on each ſide is cut a ſmall hole, large enough to receive a trough of the ſame ſize as the others; from which, to each ſide of the ſhip, lies a leading trough, one end coming through a ſally port cut through the ſhip's ſide; and the other, fixing into a communicating trough that lies along the bulkhead, from one ſide of the ſhip to the other, and being laid with quickmatch only, at the time of firing either of the leading troughs, communicates the fire in an inſtant to the contrary ſide of the ſhip, and both ſides burn together. The communicating trough, which is fixed to the bulkhead, and the leading troughs, are the ſame ſize as the others.

## Manner of preparing Stores.

### Fire Barrels.

The form of the barrels ſhould be cylindric, both upon the account of that make anſwering better for filling them with reeds, and for ſtowing them on board between the troughs; their inſide diameters are ſufficient, if about 21 inches, and their lengths 33. The bottom parts are firſt filled with ſhort double-dipt reeds ſet on end, and the remainder with fire-barrel compoſition well mixed and melted, and then poured over them.

There are 5 holes of $\frac{3}{4}$ inch diameter, and 3 inches deep, made with a drift of that ſize in the top of the compoſition while it is warm; one in the centre, and the other 4 at equal diſtances round the ſides of the barrel. When the compoſition is cold and hard, the barrel is primed by well driving thoſe holes full of fuze compoſition to within an inch of the top; then fixing in each hole

hole a ſtrand of quickmatch twice doubled, and in the centre hole 2 ſtrands the whole length; all which muſt be well ſet or drove in with mealed powder; then lay the quickmatch all within the barrel, and cover the top of it with a dipt curtain, faſtened on with a hoop to ſlip over the head, and nailed on.

The barrels ſhould be made very ſtrong, not only to ſupport the weight of the compoſition before firing, in removing and carrying them about, but to keep them together at the time they are burning; for if the ſtaves are too ſlight and thin, and ſhould burn too ſoon, ſo as to give way, the remaining compoſition would be apt to ſeparate, and tumble upon the deck, which would deſtroy the deſigned effect of the barrel, which is to carry the fire aloft.

## Iron Chambers.

They are 10 inches long, and 3.5 in diameter; and breeched againſt a piece of wood fixed acroſs the port-holes, and let into another lying a little higher; when loaded they are filled almoſt full of corned powder, and have a wooden tompion well drove into their muzzles; are primed with a ſmall piece of quickmatch thruſt through their vents into the powder, with a part of it hanging out; and when the ſhip is fired, they blow open the ports; which either fall downwards, or are carried away, and ſo give vent for the fire out of the ſides of the ſhip.

## Curtains

Are made of barras about ¾ of a yard wide, and one yard in length; when they are dipped, 2 men with each a fork (on a ſhaft of the ſame ſize, with 1 prong in each if made on purpoſe) muſt run each of their prongs through a corner of the curtain at the ſame end; then dip them into a large kettle of compoſition well melted; and when well dipped, and the curtain extended to its full breadth,

whip it between 2 ſticks of about 5.5 feet long, and 1.5 inches ſquare, held cloſe by 2 other men to take off the ſuperfluous compoſition hanging to it; then immediately ſprinkle ſaw-duſt on both ſides to prevent its ſticking, and the curtain is finiſhed.

N. B. A copper fixed with a furnace is much better than a kettle that is not fixed, becauſe it muſt be taken off from the fire for every dipping, to prevent the ſtripped off compoſition from falling into it, which would unavoidably give fire to the whole; and renders the uſe of a kettle tedious that way.

## Reeds

Are made into ſmall bundles of about 12 inches in circumference, cut even at both ends, and tied with 2 bands each; the longeſt ſort is 4 feet, and the ſhorteſt 2.5; which are all the lengths that are uſed. 1 part of them are ſingle dipped, only at 1 end; the reſt are double dipped, that is, at both ends. In dipping, they muſt be put about 7 or 8 inches deep into a copper or kettle of melted compoſition; and when drained a little over it, to carry off the ſuperfluous compoſition, ſprinkle them over a tanned hide with pulverized ſulphur, at ſome diſtance from the copper.

## Bavins

Are made of birch, heath, or other ſort of bruſh-wood, that is both quickly fired and tough; in length 2.5 or 3 feet, the buſh-ends all laid one way; and the other ends tied with 2 bands each. They are dipped and ſprinkled with ſulphur the ſame as reeds, only that the buſh-ends alone are dipped, and ſhould be a little cloſed together by hand as ſoon as done, before they are ſprinkled, to keep them more cloſe, to give a ſtronger fire, and to keep the branches from breaking off in ſhifting and handling them.

Diſpoſition

## Diſpoſition of the Stores on board, when laid for firing.

The fire-barrels are placed under the funnels and ſcuttles, 1 to each; and are fixed between the croſs troughs leading to the ſides of the ſhip, and laſhed to them, and well cleeted to the deck. Thoſe at the funnels give fire to the main and fore ſhrouds; the reſt riſe over the deck through the ſcuttles. The plugs muſt be taken out of the funnels and ſcuttles before the ſhip is fired, and the curtains covering the fire-barrels cut open and rolled back, the quickmatch ſpread, and the top of the barrels well ſalted with priming compoſition. The curtains are nailed to the beams of the upper deck, hanging down over the troughs, bavins, and reeds.

The priming compoſition; a part of it is laid along the troughs, and the reſt, after laying of the reeds and bavins, is regularly ſtrewed over all. The ſhort reeds double dipped, with ſome of the ſingle dipped, are laid along both the ſides and croſs troughs, and communicate the fire both to the barrels and chambers. The reſt of the ſingle dipped reeds and bavins are ſet about the fire barrels, and to the ſides of the ſhip; and ſome flung upon the deck.

The quickmatch is laid 2 or 3 ſtrands thick upon the reeds in the troughs, and about the fire-barrels and chambers, to communicate a general fire at once. The reeds in the troughs with the quickmatch are laſhed on, to prevent their falling out by the rolling of the ſhip.

The leading troughs are both laid with 4 or 5 ſtrands of quickmatch; as is likewiſe the communicating trough, that by firing either of the leading troughs, the communicating trough may carry the fire to the other ſide of the ſhip; which then runs along the troughs by the quickmatch on both ſides, and gives fire to the whole in an inſtant.

The

## The Compoſition made uſe of for Curtains, Reeds, and Bavins, are all the ſame, viz.

| | | |
|---|---|---|
| Pitch | 14 | N. B. For want of tar take 3 lb. of tallow. |
| Sulphur | 7 | |
| Roſin | 7 | |
| Tallow | 2 | |
| Tar | 1 | |

## Fire-Barrel Compoſition for one Barrel.

| | | |
|---|---|---|
| Corned powder | lb. | 120 |
| Pitch | | 60 |
| Tallow | | 10 |

Divide the compoſition into 5 pots; the pitch and tallow muſt be firſt thoroughly melted. Tallow well the outſide of the pot to take off the heat; and then put in the powder by ſmall quantities, ſtirring it well about.

## Priming Compoſition for one Barrel.

| | | |
|---|---|---|
| Corn powder | lb. | 100 |
| Petre | | 50 |
| Sulphur | | 40 |
| Roſin | | 6 |
| Oil | pints | 3 |

Take 20 lb. of powder, which mix well with the petre, ſulphur, and roſin; work them well together, breaking it well in working; then put the reſt of the powder in by degrees, and work it all together: ſpread it in a trough, and through a hair ſieve run 3 pints of oil all over it: then work it well together, and run it through a cane ſieve.

N. B.

N. B. In the following eſtimate for the quantity of ſtores requiſite, the reeds for the barrels are not included; it will take 100 ſhort double dipped more than theſe ſpecified; but their value is included in the article of barrels.

## Stores for a Fireſhip of 150 Tons.

| | Numb. | Value. *l.* : *s.* : *d.* |
|---|---|---|
| Fire barrels | 8 | 80 : 0 : 0 |
| Iron chambers | 12 | 12 : 0 : 0 |
| Priming compoſition barrels | $3\frac{1}{2}$ | 21 : 0 : 0 |
| Quickmatch barrels | 1 | 3 : 0 : 0 |
| Curtains dipped | 30 | 3 : 0 : 0 |
| Long reeds ſingle dipped | 150 | 10 : 15 : 0 |
| Short reeds double dipped | 75 | 2 : 18 : 9 |
| Short reeds ſingle dipped | 75 | 1 : 17 : 6 |
| Bavins ſingle dipped | 209 | 10 : 0 : 0 |
| | | 144 : 11 : 3 |

## Quantity of Compoſition for preparing the Stores of a Fireſhip.

| | pe-tre. | ſulp | corn pow. | pitch | ro-ſin | tallow | tar | oil pts. |
|---|---|---|---|---|---|---|---|---|
| For 8 barrels | 0 | 0 | 960 | 480 | 0 | 80 | 0 | 0 |
| For 3.5 barrels of priming compoſition | 175 | 140 | 350 | 0 | 21 | 0 | 0 | 11 |
| For the curtains, bavins, and reeds for the ſhip, and ſulphur for ſalting them | 0 | 200 | 0 | 350 | 175 | 50 | 25 | 0 |
| Total | 175 | 340 | 1310 | 830 | 196 | 130 | 25 | 11 |

Total weight of the compoſition 3017, equal to C. 28 : 3 : 2.

Compoſition

Compofition allowed for the reeds for the barrels one fifth of the whole of the laft article, which is equal to 163 lb. and makes the whole 3177 pounds, or C. 28 : 1 : 13.

We have completed the feveral branches of the Art of War, in eight volumes in octavo, as promifed. We have done all that lies in our power to treat them with perfpicuity and clearnefs, in order to reduce the whole to as fmall a compafs as poffible, for the fake of thofe military gentlemen who have an inclination to be mafters of their bufinefs in a fhort time. We could not enlarge upon every particular fo much as might be neceffary; yet whoever renders himfelf mafter of what we have faid, will find that nothing very material has been neglected.

# M. BELIDOR's New Method of MINING.

To which is added,

# M. VALLIERE on COUNTERMINES.

THIS work is, to ſhew the fallacy of miners in general, in regard to the effect of powder confined in mines, and to eſtabliſh the true theory of mines, upon a ſolid foundation; which being likewiſe confirmed by many unexceptionable experiments, cannot fail of meeting with the approbation of every unprejudiced reader: as to thoſe who find fault with every thing new, that ſeems to contradict an old eſtabliſhed opinion, though ever ſo erroneous, their cenſures will not be regarded; nor will any objection whatever be admitted, unleſs ſupported by well atteſted experiments.

If you imagine a large globe of earth homogeneous in all its parts, and a certain quantity of powder lodged in its centre, ſo as to produce a proper effect without burſting the globe; by ſetting fire to the powder, it is evident, that the exploſion will act all round, to overcome the obſtacles which oppoſe its motion; and as the particles of earth are porous, they will compreſs each other in proportion as the flame increaſes, and the capacity of the chamber increaſes likewiſe. But the particles of earth next to the chamber will communicate a part of their motion to thoſe next to them, and thoſe to their neighbours; and this communication will thus continue in a decreaſing proportion, till the whole force of exploſion is entirely ſpent, and the particles of earth beyond this term will remain in the ſame ſtate as they were. The

particles

particles of earth that have been acted upon by the force of explosion will compose a globe which M. Belidor calls the *Globe of Compression.*

The foregoing experiment is easily comprehended; but when powder is lodged in a mine, where the weight of the earth in the line of least resistance, is less than at the sides and underneath, it seemingly appears, that as soon as the force of explosion reaches the surface of the ground, it would throw up a certain quantity of earth, and leave a hollow in the form of a frustum of a cone, with no other effect upon the sides or bottom; as likewise, that when the mine is overcharged, the base of the excavation, instead of increasing, would rather diminish, because the force of explosion being greater would sooner reach the extremity of the line of least resistance: it is in this light, that all practical miners have hitherto considered the action of powder lodged in mines; and from thence concluded, that a certain charge will form an excavation, whose greatest diameter shall be double the line of least resistance; a less quantity raise the earth only a little, and a greater throw the earth up higher, and diminish the diameter of the excavation instead of increasing it.

As absurd as such an opinion may be, that a greater force produces a less effect than a more moderate one; yet it has prevailed amongst all the practical miners in Europe; without considering that there may be physical causes in nature, with which they were unacquainted, and that no theory of this kind should be admitted unless supported by well attested experiments.

M. Belidor made several experiments with various charges at la Fere, from which it appeared, that the greatest diameter of an excavation may not only be made double, but treble or quadruple; yet some old miners of note, who were present, could or would not believe it, though they had seen it, much less those who were absent. These experiments shewed that the diameter of the excavation could be made greater than was imagined; but for what reason, was not hitherto known, till M. Belidor demonstrated it, in the Memoirs of the Academy of Sciences

ences at Paris, in 1762, from which this work has been extracted.

To explain the reasons on which the principles of mines are grounded, it is necessary to consider not only the resistance which the weight of the earth and the cohesion of the parts make against the force of explosion, but likewise the pression of the atmosphere, which is so great as to counterbalance a column of water of the same base, and whose altitude is 33 feet, which answers nearly to a height of a middling soil of about 22 feet: so that if the line of least resistance of a mine is 10 feet, the force of explosion must not only overcome the weight of 10 feet of earth above it, but 32 feet, properly speaking. It is to be observed, that this weight resists the force of explosion no longer than till the mine bursts, and the explosion gets a communication with the air, because then the pressure of the air ceases.

Plate I. fig. 1. As the powder does not fire all at once, but gradually; so the force of explosion increases proportionally, and condenses the earth all round in a spheric form, as has been observed, till this force overcomes the resistance of the earth and atmosphere, which cannot happen before the earth rises in the middle into a spheric form, and the radius (C A) of explosion extends to the surface (A B) of the earth; and then the explosion getting a free communication with the air, raises the earth to a considerable height, and forms an excavation of a curvelined figure, such as A E B; the point C represents the centre of the powder or chamber.

It is a known principle, established by facts, that the force of explosion is always proportional to the quantity of powder fired; and as the force of explosion acts in a spheric form, and spheres are as the cubes of their radii, it is evident, that the forces of explosion, or the quantities of powder fired, are proportional to the cubes of their radii.

This proportion will always hold good in an uniform soil but varies according to the density: and if the chamber of a mine be placed on a rock, or some other hard substance, the diameter of the excavation will be greater than

than it would have been otherwife; becaufe the force of explofion being refifted downwards, will act with a greater violence towards the fides and upwards. A mine placed in a foil of a greater denfity and tenacity than another of the fame depth, requires a greater charge in proportion; but it muft be obferved, that the tenacity is not proportional to the furface of the excavation, as M. de Valliere and fome others pretend, but to the folid itfelf, as we have fhewn in page 221 of our Attack, where we treat of the proper charges of mines.

To find a proper charge of a mine in any foil, fo as to produce a given diameter, an experiment mine muft be made in the fame foil, fufficiently charged, fo as to produce a proper effect, and the line of leaft refiftance exactly meafured, as well as the diameter of the opening, by which the radius C A of the globe of compreffion will be found: then fay, *the cube of the radius of the globe of compreffion found by the experiment, is to the cube of the radius of the propofed mine, as the charge of the experiment mine is to the charge required.*

And to find the diameter of a mine whofe charge is given, fay, *the charge of the experiment mine is to the given charge, as the cube of the radius of the firft is to the cube of the radius of the fecond.* From whence the diameter required is found by this equation, $CA^2 - CD^2 = AD^2$

Amongft fome mines made at la Fere, one was charged with 170lb. and another with 300lb. the line of leaft refiftance of both was 10 feet: the diameters being meafured, the firft was found 20 feet, and the fecond 27. Now to find this laft diameter by the theory, add the fquares of 10, the line of leaft refiftance, to the fquare of 10, half the diameter 20, which gives 200, for the fquare of the radius whofe cube is 2828: then 170 : 300 : : 2828 : 4990, this fourth term is the cube of the radius of the fecond mine, whofe root is 17: and if from the fquare 289 of this root, the fquare 100 of the line of leaft refiftance be fubtracted, the fquare root of the difference will be 13.7 and 27.4, twice this root, the

diameter

diameter required: which is nearly the ſame as has been found by the experiment.

Let a mi.e be loaded with 980lb. in the ſame ſoil, and the line of leaſt reſiſtance 15 feet: then 170 : 980 :: 2828: 16302: for the cube of the radius, and its logarithm 4.21224, multiplied by 2, and divided by 3, gives 2.80826; for the logarithm of the ſquare of the radius, which anſwers to the number 643, from which ſubtracting 225, the ſquare of the line of leaſt reſiſtance, and taking the ſquare root of the difference 418, we get 20.4, and twice that number gives 40.8, which exceeds 40 feet 2 inches, found by experiment, by about 5 inches.

Having made another mine in the ſame ſoil, loaded with 3600lb. of powder, and of the ſame depth, viz. 15 feet, the diameter was found to be 70 feet: now if 170: 3600 :: 2828 : 59887, this fourth term is the cube of the radius, whoſe logarithm, 4.77733, multiplied by 2 and divided by 3, gives 3.184888 for the logarithm of the ſquare, which therefore is 1530; from this ſubtracting 225, the ſquare of the line of leaſt reſiſtance, the ſquare root of the difference 1305 will be 36, and twice this number 72 the diameter; which is 2 feet more than that found by experiment.

M. Belidor, finding the diameters of mines loaded with great charges, greater by computation than by experiments, imagines that it was owing to the cubical chambers, by which the quantity of earth above them is leſs in proportion than in ſmall ones: but whether this reaſon is juſt, or that the diameter and the line of leaſt reſiſtance have not been rightly meaſured, is not certain; for a friend of mine found the contrary in ſome very accurate experiments he made.

Having given an account in page 232 of our Attack, of ſome experiments formerly made at la Fere, and computed their diameters from the parabolic figure, we ſhall here compute the ſame diameters from the globe of compreſſion. The firſt was loaded with 120, the ſecond 160, the third 200, the fourth 240, the fifth 280, the ſixth 320, and the ſeventh with 360: the line of leaſt reſiſtance was

10 feet in all of them; the diameters were found to be, 1ſt, 22 $\frac{2}{3}$, 2d, 26, 3d, 29, 4th, 31$\frac{1}{2}$, 5th, 33$\frac{1}{2}$, 6th, 36, 7th, 38 feet. Now taking the diameter of any one as known, for example, that of the ſecond 26, whoſe globe of compreſſion will be found to be 4412; then as the globes of compreſſion are proportional to the charges, they will be, 1ſt, 3309; 3d, 5515; 4th, 6618; 5th, 7721; 6th, 8824; 7th, 9927: the ſquares of their radii, 1ſt, 225.05; 3d, 312.15; 4th, 352.49; 5th, 390.64; 6th, 427.02; 7th, 461.9; and the radii of the baſes, 1ſt, 11.05; 3d, 14.56; 4th, 15.88; 5th, 17.04; 6th, 18.08; 7th, 19.02; whence the diameters are, 22.1; 29.12; 31.76; 34.08; 36.16; 38; which ſhews that the greateſt difference between the meaſured and computed diameters is not above 6 inches.

The near agreement between the diameters, computed from theſe two different methods, ſeemingly ſo different, appears extraordinary. I found beſides, in computing large tables by both of them, that one gave the charge ſomething greater than equal, and afterwards leſs than the other; but the differences were immaterial.

We have hitherto computed the diameters of mines from their charges; we ſhall now give ſome examples to ſhew how to find the charges, from the given diameters. Thus a mine made in the ſame ſoil as the laſt ſeven, whoſe line of leaſt reſiſtance is 10 feet, it is required to find the charge ſo as to make a diameter of 40 feet: the ſum of the ſquares of the line of leaſt reſiſtance 10, and half the diameter 20, gives 500 for the ſquare of the radius of the globe of compreſſion; and the ſquare root 22.36 of 500, multiplied by 500, gives 11180 for the globe of compreſſion; then the globe of compreſſion 4412 of the ſecond mine, is to the globe of compreſſion 11180, as the charge 160 of the experiment mine is to the charge required, which will be 405lb. nearly.

Let a mine whoſe line of leaſt reſiſtance is 10 feet be loaded with 170lb. of powder, and have a diameter of 20 feet; it is propoſed to make another in the ſame ſoil, whoſe line of leaſt reſiſtance is 15 feet, and its diameter 70.

70, to find its charge. The ſquare 1225 of half the diameter 70, added to the ſquare 225 of the line of leaſt reſiſtance 10, gives 1450, whoſe root is 38 nearly; and 1450, multiplied by 38, gives 55100 for the globe of compreſſion, and as the globe of compreſſion of the experiment mine has been found above to be 2828, we have 2828 : 55100 : : 170 : 3312lb. of powder for the charge required.

M. Belidor ſays, to ſhew the application of the globe of compreſſion in the defence of places, I ſhall explain the planes and profils of countermines made at la Fere, to blow up the beſiegers cannons, and throw them into the ditch, together with another experiment, which threw the cannons into the fortification.

It is well known, that when once the beſiegers have eſtabliſhed their batteries near the covered way, to make a breach in an outwork, or the body of the place, they become practicable in 2 or 3 days, then the beſieged are obliged to ſurrender; ſo that the only reſource remaining to them, is to retard the finiſhing theſe batteries as much as poſſible, by all the ſtratagems that can be imagined; but nothing diſconcerts the beſiegers ſo much as the deſtroying them by countermines, and to throw the cannons into the poſſeſſion of the beſieged.

Every time that batteries have been deſtroyed by countermines, the cannons have been thrown into the trenches, becauſe the reſiſtance is greater on the ſide of the parapet than on any other; but when the ſame ground is blown up ſeveral times, the chambers may be ſo diſpoſed, that when the beſiegers have re-eſtabliſhed their batteries for the ſecond or third time, the cannons may be blown towards the place; becauſe the earth to fill up the excavation having much leſs tenacity than the former, that ſide which was the ſtrongeſt becomes the weakeſt.

By following this method, I have in 1724 conſtructed countermines under the glacis of the polygon at la Fere, to blow up the batteries ſuppoſed to be erected by the beſiegers three times.

Plate I. Fig. 2, 3, 4. The firſt chamber C, blew up two 24 pounders towards the trenches as uſual: the batteries being re-eſtabliſhed, the chamber D threw the cannons into the ditch: the batteries being re-eſtabliſhed again, the chamber E threw the cannons again into the ditch, to the great ſurpriſe of the ſpectators, eſpecially to ſome of the miners, who expected quite the contrary. For it was the firſt time that this method had been practiſed except at the ſiege of Turin in 1706, where by chance one of our pieces was thrown into the covert-way, which the beſieged carried in triumph into the town.

As ſuch an advantage is extremely proper to raiſe the courage of the garriſon, and to diſcourage the beſiegers, by the length of time to re-eſtabliſh the batteries, we thought we could not ſhew better our attachment to his majeſty's ſervice, than endeavouring to improve this branch of the countermines, in ſuch a manner, that the firſt mine, called fougaſſe, having only eight or ten feet of the line of the leaſt reſiſtance, may throw directly the enemy's guns into the ditch of the place, and even into the work, in order to make uſe of them againſt him. This method may be uſed in places which have wet ditches as well as the dry; ſince by ſinking only 3 feet under the level of the covert way, the height of the banquet and parapet give 7 feet more, this makes a ſufficient line of leaſt reſiſtance to blow up a battery. If 8 feet can be ſunk inſtead of 3, the battery may be twice blown up, and a third time if 13 or 14 feet can be ſunk. The queſtion is then to throw the cannons the firſt time into the ditch; for after that, there is no doubt but it may be done again as often as the enemy attempts to raiſe them, and the depth of the ground will allow it.

This project being ſent to court, was ordered to be put in practice in 1739; for which reaſon a battery was raiſed in all its forms, for two 24 pounders. Under the middle of which a gallery F G, fig. 5, 6, was made from the foot T, of the banquet of 20 feet long, from which 2 branches GH, GI, were made, each of them 7 feet long, to place the chambers A A, whoſe lines of leaſt

leaſt reſiſtance was 7 feet only, being under the axle-trees of the pieces; the gallery was continued in a ſlope, to make from thence 2 other branches K L, K N, in the ſame manner as the preceding, but lower, to place the chambers B, B, whoſe line of leaſt reſiſtance was 10 feet, and at the ſame diſtance from the former A, taken horizontally, in order to have the right angled iſoſceles triangle B D C, fig. 5, whoſe hypothenuſe B C, ſhews the direction of the action of the powder.

The intent of the little chambers A, A, being to overcome the tenacity of the ſoil, without any other effect, were charged each with 20 pounds of powder only, whereas the others B, B, were each charged with 600 pounds. The length of the leaders were contrived ſo as the fire being ſet to it at F, it went to G, and from thence to the chambers A, A, and to the point K at the ſame time, and to the chambers B, B, in a few ſeconds afterwards: the firſt, A, A. having produced a proper effect, the ſecond B, B, met with leſs reſiſtance towards the wheels of the carriages than towards the trail, raiſed the pieces to about 40 fathoms, and then threw them 35 fathoms from the battery into the ditch.

The effect of theſe mines was much greater than expected, even by thoſe who had the moſt favourable opinions, from the bare expoſition of the project: the moſt expert in mines at la Fere were more ſenſible than ever of the certainty of the principles eſtabliſhed in our theory, and of all the advantages that may be obtained from the globe of compreſſion.

Though the centres of the two chambers were 18 feet from each other, they yet produced but one excavation of an elliptic form, whoſe greateſt diameter was found to be 45 feet, and the leaſt 27; the depth 18, and the bottom well cleared, without hurting the parapet of the covert way. If then 2 mines produced ſo great an excavation, to what extremity will the beſiegers be reduced if a battery of 10 or 12 pieces was blown up: for where will they find earth enough to fill up an excavation of 35 or 40 fathoms in length, 5 in breadth, and 15 feet deep?

What time will be loſt in repairing all theſe damages; and what deſtruction there muſt be amongſt the ſoldiers, from the fire of ſhells, carcaſſes, and granades, continually thrown into ſuch a confined place!

## Experiments made at Bisy in July, 1753, by order of the French King, together with their Uſe in the Attack of Places.

THE intent of theſe experiments was to render uſeleſs the countermines of a beſieged town, by burſting the galleries all round, above and below, to a certain diſtance, or to change theſe galleries into ſo many trenches, by which the covert-way may be taken at once with very little trouble. His majeſty being informed of theſe means, ordered that experiments ſhould be made near the caſtle of Biſy, belonging to the duke of Belleiſle. In conſequence of which, a detachment of 75 miners, with their officers, was ſent there from the artillery ſchool at la Fere. The work begun with what belongs to the globe of compreſſion; a ſoil had been pitched upon the moſt uniform that could be found, which happened to be a hard ſand, mixed with gravel; there were made 4 galleries, A, B, C, D, fig. 7, 3 feet wide, and 6 high, ſo as to form a rectangle, whoſe ſides anſwered nearly to the 4 cardinal points: the 2 oppoſite ones A, B, which faced the north and ſouth, were each 10 fathoms long, and the other 2 C, D, which faced the weſt and eaſt, 12 fathoms; they were lined with ſtones, in order to ſhew that maſonry was rather an advantage than an obſtacle to the effect of powder: the bottom of theſe galleries had a ſlope of 6 feet 3 inches, and the mean depth was 15 feet under the ſurface of the ground, which terminated in a deſcent from ſouth to north, between the interval of the galleries of that name. In that to the eaſt, C, a branch, L K, was made at right angles of 24 feet long, and at K another, K F, at right angle to this, to place a chamber, E, 30 feet diſtant from the gallery A, 36 from D, and 42 from B.

B. The other galleries were made by means of 2 ſhafts or pits, M, I, the one M, to the ſouth was 16 feet deep, and the other, I, to the north 20.

When theſe galleries were finiſhed, the laſt pit, I, was deepened nine feet more; ſo that the bottom Y, fig. 8, was 29 feet below the ſurface of the ground near the chamber. After this a gallery, YX, was made going directly under the chamber E, with a deſcent of 18 inches, and 5 feet high, by which its top was 14 feet below the centre of the chamber E, the whole ſupported with ſtrong planks of oak, and ſtill in the ſame ſort of ſoil as mentioned before, but ſo hard, that the miners were obliged to uſe the chiſſels. Such was the diſpoſition made to what belonged to the globe of compreſſion; whoſe object was to ſee whether it would burſt all theſe galleries.

As it does not appear natural, that a mine, whoſe effect ſhould be on the weakeſt ſide, would burſt galleries at a diſtance of 4 times the length of its line of leaſt reſiſtance, it is no wonder that it ſhould have been doubted; though the experiment made at la Fere in 1732, ſhould have been a proof of it, as the fact was eſtabliſhed upon the preceding theory, yet the miners were not convinced, pretending, that the powder had penetrated between the ſoft ſoil and a bed of ſtrong clay, ſo far as to burſt the gallery. It was plain, that by admitting this theory, the old, and all its conſequences, muſt of neceſſity be rejected. I kept ſilence upon this article till 1753, when, in a diſcourſe which I had the honour to make to his majeſty on the effect of powder in mines and fire-arms, he ordered immediately that I ſhould be furniſhed with means to make farther experiments, which are thoſe I have now deſcribed.

The 18th of June, the count d'Argenſon, who arrived the night before at the duke of Belleiſle's, at the caſtle of Biſy, with ſome general officers and other perſons of quality, who came there out of curioſity, went early in the morning, to viſit all the works of the mines; after this fire was ſet to the globe of compreſſion, which

had been loaded the night before with 3000 lb. of powder: it raised the earth to about 150 feet high. They then went to see whether it had destroyed the galleries about it, as well as those underneath, and to what distance the globe of compression had acted; it was found that it formed an excavation perfectly round of 66 feet diameter, and 17 deep.

The east gallery C, lined with masonry, and at 24 feet distant from the chamber, was entirely burst from one end to the other.

The south gallery A, at 30 feet distant from the chamber, was equally burst from one end to the other, except 2 fathoms near the entrance M, at the west.

The west gallery D, of 12 fathoms long, and 36 feet distant from the chamber, was destroyed to the length of 7 fathoms, 3 fathoms were left near its entrance at the north, and 2 fathoms on the other end.

The north gallery B, which was 10 fathoms long, and 42 feet from the chamber, was destroyed all but 2 fathoms at its entrance at the west, so there was 8 fathoms impracticable, which were divided into 2 equal parts by the perpendicular drawn from the centre of the chamber to that gallery.

As that line formed a right-angled triangle, with half the gallery destroyed, whose hypothenuse is 48 feet; which hypothenuse is the radius of the globe of compression; this shews that the globe of compression would have destroyed a gallery at that distance, and consequently quadruple the line of least resistance.

The gallery Y, Z, S, fig. 8, which passed under the chamber E, whose top was 14 feet from it, and length 69 feet, could not be entered farther than the length Y Z of 24 feet, so that 45 feet of it was destroyed; as the extremity of this gallery was 9 feet beyond the centre of the chamber, it appears that there remains 60 feet from the middle to the entrance, and as there were 24 feet not destroyed, there remained 36 destroyed on that side, which taking for the base of a right-angled triangle Z S E, and the perpendicular E S being 14 feet, the

the hypothenuſe E Z, is found to be 38 feet, which therefore is the radius of the globe of compreſſion: ſo that it would have deſtroyed a gallery whoſe top had been at that diſtance under the mine, conſequently 50 feet under the ſurface of the ground, which is the greateſt diſtance that a gallery can ever be made. Theſe are facts yet extant, and which may be verified upon the ſpot.

From hence it follows, that if the line of leaſt reſiſtance had been 15 or 16 feet inſtead of 12, the globe of compreſſion would have deſtroyed a gallery at 60 feet diſtant from the centre of the chamber; conſequently if the chamber was placed at that depth, and nearly in the middle between two liſtning galleries, whoſe diſtance is generally from 15 to 24 fathoms, it would have burſted both the envelope and all thoſe under and above them, by increaſing only the quantity of powder in proportion. This proves the great uſe that may be made of the globe of compreſſion, in the attack of a place countermined.

It has been found, that to make uſe of the globe of compreſſion in a common ſoil, the chamber ſhould be made upon the ſame level with the galleries, and its greateſt diſtance be about quadruple its depth nearly; then the diameter of the excavation will be about ſextuple that line. And to find the charge, *multiply 3 times the line of leaſt reſiſtance, expreſſed in feet by* 100, *and the product will give the number of pounds of powder for the charge required.* For example, having 2 or 3 contiguous galleries, 15 feet deep, at a diſtance not exceeding 60 feet; make a ſhaft in the moſt convenient place, and from thence carry a branch to eſtabliſh the chamber: then 3 times 15, the depth of the mine, multiplied by 100, gives 4500 lb. for the charge of this mine. From this rule it appears, that the true charge of the globe of compreſſion at Biſy ſhould have been 3600 lb. for a line of leaſt reſiſtance of 12 feet, then the diameter of the excavation would have been 72 feet inſtead of 66, and in that caſe the weſt gallery would have been deſtroyed to the

the quadruple of the line of leaſt reſiſtance, as already mentioned. The reaſon for charging the mine of Biſy with 3000 lb. only, was to prevent ſome houſes near it, from being damaged. This rule for charging mines is not founded on any exact theory, but is ſufficiently exact, becauſe it is better in this caſe, to make the charge greater than leſs.

While part of the miners detachment was occupied in what belonged to the globe of compreſſion, the other was at work to conſtruct a place of arms of a covert-way to countermine it; in order to change them afterwards into trenches of a ſiege, and to furniſh means of a new kind of experiments. This place of arms traced ſuch as one in a real fortification was found to be in a moſt ungrateful ſoil, for the bottom was of a very hard free ſtone, that could not be penetrated without blowing it up; and it was covered with a ſtrong clay, which appeared to be againſt the intended experiments; but as it would have been looked upon to favour the experiments, by changing the ſituation, it was thought proper to continue the work in that ſoil which had been pitched upon by chance, ſo that if they ſucceeded in this, there would be no doubt of their ſucceſs in any other.

Plate II. Fig. 12. At the depth of 12, 13, 14, and 15 feet, were made a gallery *magiſtrate* 1, 2, 3; an *envelope* 4 7, at the foot of the glacis; 2 traverſing, 1, 4 and 3, 7; and 2 *liſtner*, 5, 8 and 6, 9; all being 5 feet high, and 3 broad. This work being finiſhed, a ſap, B C, was made in the uſual form, which croſſing one of the liſtners, and within about 4 fathoms of the other, as happened by chance. The 16th, the beſieged miners intending to deſtroy this head of the ſap, ſet fire to the mines A, B, carried from the liſtner at the right. The ſecond mine B, which was 10 feet deep, formed an excavation of 27 feet diameter, in which the miners entered to diſcover the gallery, cleared it, and from thence entered into the liſtner, which was done in 5 hours.

The

The 1;th, the beſiegers intending to deſtroy, at the ſame time, and by the ſame fire, the liſtner of 20 fathoms, the envelope of 24, and 12 of the traverſing; in order to which, they begun at the right to place ſand bags before them ſerving as a retrenchment, then placed the leaders and put ten barrels of powder in two heaps at the end of the traver ng gallery; 16 in 4 heaps into the envelope, and as much into the liſtner; and ſtopped up the entrance at the excavation: all this work was finiſhed in 7 hours.

The count d'Argenſon being arrived, the beſieged miners ſet fire to the mine C, at the left, which they had loaded with 200 lb. of powder, in order to deſtroy the ſap on that ſide. The beſiegers miners entered into the excavation, to diſcover the gallery; in the mean time the beſieged ſent 2 miners, followed by lord Melford, out of curioſity, to obſerve the beſiegers, who being arrived at the envelope, the ſmoke of the leader was ſo great, that they could proceed no further; then retired in haſte into the freſh air, to recover from the ſuffocation they were affected with in the attempt.

An hour after, the ſame lord, with a ſerjeant and a corporal, entered a ſecond time into the gallery, to ſee whether they could advance farther, but found the ſtench of the powder ſtill worſe than the firſt time; for attempting to go into the liſtner, they ſwooned away, and would have died, had they not been carried out directly, eſpecially the corporal, who did not recover in 24 hours. This example ſhews, that the miners have not a more cruel enemy than the confined ſmoke of powder; for if they are in it during a few minutes, faint away, and die if not properly ſecured.

After this event, fire was ſet to the leader on the right, which ſuddenly raiſed the upper part of the liſtner, the envelope and part of the traverſing, and changed them into trenches, as in fig 13. to the length of 56 fathoms, being about 24 feet broad, and about 8 deep; a little after

after were ſprung by the ſame fire, the reſt of the communication or traverſing adjacent, with half the magiſtral in the gorge of the place of arms, by means of 24 barrels of powder placed in ſix heaps, which changed theſe galleries alſo into trenches, the length of 38 fathoms, that is, the liſtner on the right, the envelope, the traverſing, and the magiſtral, formed one continued trench.

The ſame day the miners, after having cleared the bottom of the excavation near the liſtner at the left, opened the gallery and penetrated into the liſtner, charged it and the traverſing with 20 barrels of powder placed in 4 heaps; they charged likewiſe the other half of the magiſtral gallery, in the place of arms, with 12 barrels of powder placed in 3 heaps.

Things thus diſpoſed, the count d'Argenſon and the duke of Belleiſle came the 19th, to ſee the remainder of the operations; the firſt changed the liſtner, which was 22 fathoms long, into a trench with more ſucceſs than the former, as being better cleared; after this, the reſt of the magiſtral gallery was ſprung, which made a trench of 20 fathoms. Theſe trenches may be traverſed and finiſhed, as in fig. 14.

It may perhaps be ſaid, that as theſe countermines were not defended, it is no wonder that theſe trenches were ſo eaſily made: but this objection deſerves no anſwer; it is ſufficient, that the operations made here are what is daily practiſed at the ſchool of artillery, without any body receiving the leaſt harm.

All theſe experiments being finiſhed to the ſatisfaction of the count d'Argenſon, without any accident, that miniſter, to verify them to the king, had a memorial drawn up, and ſigned by Meſſrs. Valiere, Gourdon, lieutenant generals; d'Auville, Chateauſer, Gribauval, captains of miners; Belcourt, third commander of the ſchool of artillery at la Fere and Belidor.

It is after this memorial that the preceding facts have been written, which cannot be ſuſpected of any alterations,

tions, every thing was approved of by all who were invited by M. Count d'Argenſon, to ſee them.

From theſe experiments has been deduced a method for changing galleries of mines into trenches, viz. after having ſtopt the entrance with ſand bags or wood, the heaps of barrels of powder ſhould be placed at equal diſtances from each other, to make them take fire together, and this diſtance ſhould not exceed triple the depth of the gallery, from thence the length of the leaders will be determined. The charge ſhould not be too great, to prevent the making too deep a trench, for the ſoldiers to defend them; each heap of powder ſhould contain as many barrels of 100 lb. as there are feet in the fourth part of the depth of the gallery, in a common ſoil. For example, having a gallery of about 24 fathoms, and 16 feet deep, there ſhould be 4 barrels in a heap, and 4 heaps, diſtant 6 fathoms from the centre of the one to the centre of the next, and half that diſtance from the ends. This may be done in 4 hours. If the galleries were ſituated in a different ſoil, than that we have here ſuppoſed, a trial muſt be made to determine from thence the proper charge.

To account for the effect of powder in galleries of mines changed into trenches; I conſider that theſe galleries are in the ſame caſe as a muſket that is to be burſt, which requires not to be charged with a great quantity of powder. For if its end be well ſtopped, when the powder is fired, the flame being prevented from ruſhing out, endeavours to extend itſelf, till a ſufficient quantity is fired to overcome the obſtacle that reſiſts it, opens the barrel from one end to the other. The ſame thing happens in galleries of mines; for when the heaps of powder are properly diſpoſed, and the leaders ſo contrived as the ſeveral heaps take fire at the ſame time, the flame extends all over till a ſufficient quantity is lighted to burſt the gallery. From hence it follows,

1. That the method of changing galleries of mines into trenches, will be of excellent uſe, eſpecially when the ſoil is gravel or ſtony, which is improper to proceed

ceed by ſap; for this is no hindrance to the effect of powder, as found by the experiments made at Biſy.

2. That the countermines, as commonly made in a fortified place, are a diſadvantage to the beſieged inſtead of an advantage; eſpecially, if the beſiegers have plans and profils of them, becauſe they cannot ſpring an advanced mine, without giving the enemy an opportunity to burſt their galleries, and advance to the covert-way with very little trouble, and to erect batteries with ſecurity.

3. Henceforward, the chance of the beſieged and beſiegers will entirely be changed, ſince the latter will find diſpoſitions ready prepared, which will turn more to his advantage, than the place could formerly have received from them.

4. That in the attack of places countermined, the beſiegers miners will be of much greater importance than ever; ſince the taking the covert-way will be their lot, as well as all thoſe works which have under-ground communications with the place, ſuch as the citadel of Tournay and many others, and the place itſelf, if it has any ſuch paſſages.

5. That the preſent method of making countermines, leading towards the covert-way, muſt neceſſarily be changed, in order to prevent the enemy from turning the galleries to his advantage.

Plate III. Fig. 17. To apply our method of attacking the countermines in a place beſieged, I ſuppoſed, the firſt and ſecond parallels made the latter A, B, C, to be diſtant of about 60 fathoms from the palliſades of the covert-way, and from thence the trenches are carried on in the capital of the ravelin, and in thoſe of the adjacent baſtions of the front attacked; and after this, batteries L are made of cannons and mortars to enfilade by ricochet, the covert-way, and the ramparts parallel to it, to deſtroy their defences. During this time, the ſapers carry on the ſaps towards the places of arms in the covert way, both ſaliant and rentring; to eſtabliſh the heads E F near the ends of the liſtners G, G, before the

the faliant angles, and the miners proceed under-ground to place chambers I, overcharged, between the extremities of the liftners of the re-entring angles: I fuppofe they have taken the precaution to fink their fhafts as deep as the countermines, that the chambers may nearly be upon a level with the galleries, and that the fhafts are placed in the trenches K, which lead from one battery to the other, not to interfere with any other works; from the bottom of thefe fhafts they make the galleries K L of about 20 fathoms long. This will be a work of 4 or 5 days to the eftablifhing their chambers, which fhould be finifhed at the fame time, that they may be fprung together; the fapers will by this time be arrived to the heads E F, to induce the befieged to fpring fome of their mines, to deftroy them; with a little attention his intention may be difcovered time enough to withdraw the troops.

Suppofing, that they have fprung 2 or 3 mines at each fide, as foon as this is done, the miners enter into the excavations to difcover the galleries, which they muft do at the fame time, while the fapers form a lodgment in the excavation. When the galleries are found and cleared, they ftop up their entrances, to keep in the fmoke till they want to make ufe of them. On the other hand, all the globes of compreffion are fired, and from their excavations fearch is made on the right and left to difcover the liftners; fo that, if the meafures have been rightly taken, 14 entrances into the countermines will be found, by which it will be out of the befieged's power to refift equally every where; fhould there be but half that number practicable, it would be fufficient to get poffeffion of all their mines; of which, only thofe that are convenient to advance the fiege, are to be changed into trenches.

## Obfervations on the preceding Theory.

That this theory grounded on the globe of compreffion, is a great improvement upon the art of mining, muft

muſt be allowed: the experiments made at Biſy and la Fere, before many military gentlemen, demonſtrate its great effects, and intirely overſet that old erroneous opinion, hitherto believed by miners in general, that powder confined in mines acts on the weakeſt ſide, and not downwards nor ſide-ways. Since galleries were deſtroyed under and at the ſides of the chamber, at the diſtance equal to four times the line of leaſt reſiſtance; whereas before it was ſuppoſed that it could not make the diameter of the excavation above twice that line. Therefore, as long as this erroneous opinion, inſiſted upon by all authors, ſubſiſted, the theory of mines could not be brought to any degree of perfection.

The method of throwing the cannons of batteries placed on the covert-way, into the ditch, is no leſs important, ſince nothing can diſhearten the beſiegers ſo much, as to ſee their batteries for making a breach deſtroyed as oft as they attempt to raiſe or repair them. It may be obſerved that the ſmall mines A, Plate I. fig. 6. ſeem not to be abſolutely neceſſary, provided the great ones B, are placed directly under the breech of the gun; for in this caſe, as the part of the gun and carriage towards the place is much heavier than the other, if the mine be properly charged, muſt throw the guns towards the ditch, without the help of theſe ſmall mines; for this has been effected by one mine only, at Byfleet camp, ſome years ago, by Matthew Clark, one of the greateſt engineers of his time.

The greateſt advantage of this theory conſiſts in changing the galleries of countermines into trenches of an attack; ſince it reduces the moſt dangerous and difficult part of a ſiege, which is that from the third parallel to the intire poſſeſſion of the covert-way, into a very ſhort and ſafe method, ſuppoſing the place countermined. This method is however liable to ſome objections: M. Belidor mentions one; which is, *that it may be ſaid, the countermines in the place of arms not having been defended, it is not to be wondered that ſuch an advantage has been made of them:* without any other anſwer than what

what is daily practised at la Fere. Now if the besieged are prevented by the smoke to enter into the galleries, does not the same difficulty obstruct the besiegers? It is true, he says afterwards, that the entrance from the excavation is kept stopped till they want to use them, and when opened, the air enters at one end and drives out the smoke through the other. But then so soon as the gallery is cleared from the smoke, it may be entered at both ends, by which the besieged can with an equal advantage defend them, as the besiegers to get possession. And if the besieged are aware of the enemies design, they may stop the entrance on their side, by which it will be impossible for them to make use of them against the place. It is true that the besieged deprive themselves of the use of the rest of their countermines, unless they are loaded and stopped beforehand, which is not to be done in certain circumstances.

If these stratagems should be foreseen by the besieged and prevented mostly, yet by means of the globe of compression, their galleries may be destroyed so as to be quite useless, the besieged will be enabled to proceed in their trenches, and raise their batteries without any other disturbance but from above-ground. From whence it clearly appears, that the countermines, formerly the greatest obstacle of a siege, are now of very little advantage to a fortified place.

The great effect of powder, though not confined, as hitherto thought necessary, has been known long ago. In the duke of Sully's memoirs, page 136, octavo edit. vol. I. we find this remarkable passage; "the king of Navarre took Monsegur. Captain Milon "inclosed five hundred pounds of powder in a bag, "which he found means to introduce into a drain, from "the town into the ditch between two principal gates "of the town; the end of the leader was hid in the grass. "Every thing being ready to play off this machine, "the king gave us leave to go and see its effect; which "was surprising. For one of the gates was thrown "into the middle of the town, and the other into the

" field, fifty paces from the wall: all the vaults were " destroyed, and a passage was made in the wall for " 3 men to enter a-breast, by which the town was " taken."

## M. Valliere's Dissertation on Mines, and their Advantages in the Defence of Places.

I shall not give, in this dissertation, the construction of mines or countermines, the position of listners, chambers, their charges, nor the manner of using them; but only a general idea of the advantages which may be drawn from countermines, if they were constructed and defended as they should be. To explain every thing, it would be necessary to enter into the particulars of the practice, besides trigonometry; treat of the theory of the collision of bodies; the communication of motion; the resistance of solids on the various forces of percussion, and elasticity of the flame, arising from different quantities of powder on the time; the different manner of its inflammation, in different fire-arms, according as the fire is conveyed; and, in short, into the physico-mathematical knowledge, which requires a chain of demonstrations sufficient to fill a large volume, of which this discourse could only serve as a preface.

When Spain made the conquest of the kingdom of Naples from the French, Francis George, an Italian architect at Naples, proposed to Peter Navarre, the Spanish general, besieging at that time the castle del Ovo, a method of becoming soon master of this castle; the French who defended it, were the first who felt the effect of powder in mines; the architect, whether by knowledge or by chance, placing the powder in such a manner, that he threw the wall and garrison into the sea. This was then the origin of the artificial vulcano, invented to facilitate the taking of places; but it is found on the contrary, that it is more advantageous in the defence, without having as yet been rightly considered.

It

It is known, that the perfection of arts and fciences is referved to fucceeding generations. With refpect to the fcience of mines, judging from what has been practifed, there are certain principles, which, according to all appearances, have not as yet been difcovered; and from which are deduced fuch facts and advantageous means for the defence of places, as would be unpardonable in us to have neglected.

What I have feen beft on the effect and conftruction of mines, are memoirs, containing feveral experiments of mines made fince thefe twenty-five years; giving the charges of mines pretty exactly, and the diameters of the excavations, according to their different lines of leaft refiftance; I fay pretty exactly, becaufe there is a certain rule and geometrical accuracy to be obferved in thefe things, not mentioned in thofe memoirs. For inftance, it has been found in practice,* that a lefs quantity of powder is required, in proportion to the earth, in large mines than in fmall: the reafon given by fome is, that a great quantity of powder producesa greater force in proportion than a lefs: but thofe that argue in this manner would foon have difcovered their error, had they confidered, that not only the weight to be raifed is to be confidered, but likewife the tenacity of the parts; and as the tenacities are proportional to the furfaces, and the weights to the folid formed by the excavation; and the furfaces of large bodies are lefs in proportion than in fmall; the charges of large mines fhould be lefs in proportion than thofe in fmall.

This difcourfe on the proportion of charges only, fhews the neceffity of geometry in the ufe of mines; the bare knowledge of the practice is not fufficient to underftand what has here been faid: there are befides other cafes, wherein it rarely fucceeds, though it be fufficient in the



* All the fubfequent argument appears to be without foundation, by all the experiments made at la Fere at different times. For it was found that the charges were always proportional to the quantities of earth blown up, or the globe of compreffion. M. Valliere has not leffened the charges of large mines in his tables; which alfo contradict what is here faid.

attack of a place not countermined; becaufe when nothing obftructs the miners paffage, it is eafy to blow up a counterfcarp and make a breach in a baftion, and if fome mines do not fucceed, it is owing to the ignorance, fcarcely pardonable, of thofe who undertake to conftruct them, unlefs fome unforefeen heterogeneous matter intervenes, and forces the powder to act differently from what it would have done in an uniform foil; but this accident happens oftner through ignorance than any thing elfe, becaufe a fkilful miner commonly knows where thefe inconveniences are to be apprehended, and if he does not know how to remedy them, he fhould at leaft give notice to the general.

It has not yet been rightly diftinguifhed, how far the word Countermine agrees to mines prepared for the defence of places; all know how much they intimidate the befiegers, but the harm they have hitherto done is nothing in comparifon to what they may do, and what obftruction they may make. I fhall not pretend to fay, that they may render a place abfolutely impregnable, but I do not fee how, with equal fkill, to overcome all the obftacles, nor to fucceed in an attack of a place countermined properly, and fkilfully defended.

It is prefuppofed that I mean the fituation of a place proper for mines, well fortified, with a fufficient garrifon to defend it, provided with warlike ftores, provifions, and every thing elfe, which experience has fhewn to be neceffary.

A miner that knows how to ufe countermines conftructed as they fhould be, may ftop the enemy's miners, ftifle them, or deftroy their works in fuch a manner, as to make it impoffible for others to return to the fame place, or, if he pleafe, let them enter the galleries, block up the paffage, and take them prifoners, or kill them if thought proper. In fhort, the befieged who know how to take all advantages, will be mafter of the fate of their enemies: for without mentioning all the traps and ftratagems which the enemies cannot forefee; finding it impoffible

poſſible to advance, and the under-ground paſſages being ſtopped, and not being able to make mines that can be of any uſe to them; if neceſſity obliges him to brave the mines, and to carry on the attack above-ground, he muſt be very obſtinate to perſiſt in ſpite of all the hardſhips that the beſieged can make him endure, not only in making his approaches, but likewiſe in making his lodgment on the covert way, and every where elſe, where he dares to carry on this work.

If he proceeds by ſap to the covert-way, it will be proper to give him notice from time to time, by ſome mines, of the danger he is in; if he makes his attack ſword in hand, mines appear then uſeleſs; yet they may ſtartle the troops during the attack, and bury ſome men; but as the excavations may ſerve for lodgments, it will be better to reſerve the mines for diſturbing the work, and conſequently to gain time; beſides, theſe firſt mines ſhould not be loaded till they are to be uſed, in order to be always ready to prevent the enemy from advancing, which cannot be done, if they are charged before. The enemy being arrived to the covert-way, may attempt to re-enter the ground, whilſt he compleats his lodgment; but he will again be obſtructed, and find on all ſides the ſame difficulties as before. So ſoon as he begins to raiſe batteries for making a breach, it will be proper to deſtroy all the lodgments on the covert-way by the uppermoſt mines, for very good reaſons, and not wait till the cannons are mounted; for theſe ſmall mines looſen the earth where the cannon are to be, by which the next mines will throw the cannon, when mounted, towards the town. Theſe batteries being repaired, and the cannon mounted, which cannot be done in a ſhort time, the mines, which I ſuppoſe properly diſpoſed and charged, will throw the cannon, a ſecond time, into the ditch of the place. Such an adventure muſt aſtoniſh an enemy, for here is another battery and lodgment to be made; and when other mines throw the cannon again into the ditch a third time, if he is bold enough to venture raiſing batteries again, he will meet with the ſame reception. In ſhort, when there is a depth of earth

of 25 or 30 feet, it is eaſy to blow up the ſame ſurface near the covert-way, 6 or 7 times, which certainly is more than ſufficient to diſhearten the moſt obſtinate enemy.

Theſe mines ſhould be diſpoſed in ſuch a manner as not to damage the parapet of the covert-way, that it may remain in a condition to be occupied as oft as the lodgment is demoliſhed; at the ſame time the ſaps, communications, and parallels, by which the enemy maintains his lodgment on the covert way, muſt not be ſpared, ſome mines muſt continually be ſprung, with the precaution to deſtroy always thoſe works which are found moſt complete.

It muſt here be obſerved, that if the depth of earth near the covert-way admits of being blown up 6 or 7 times, it is eaſy on a level ground of that depth to diſpoſe the chambers of mines in ſuch a manner, as to blow up the ſame ſpot 20 times all over the glacis and beyond it, becauſe they are not confined on one ſide, as thoſe near the covert way.

If the mines made it impracticable to make a breach with cannons, and yet the enemy is obſtinately bent to purſue his enterprize, what meaſures can he take? Will he have recourſe to eſcalades? This ſcheme is chimerical, and little to be feared, for a garriſon that knows how to defend itſelf. I mention this, becauſe I happened to be at Landau when beſieged in 1704, where the garriſon, brave as it was, having done all that could be expected, were at laſt in fear of an eſcalade; on which ſuſpicion, they determined, after 2 days debate, unſeaſonably to let the water into the ditch. Will the enemy have recourſe again to mines? There are but two ways to arrive at the place or outwork; the one, to paſs under the ditch from the covert-way; a tedious work, in which he certainly will be obſtructed; the other, to throw the counterſcarp into the ditch, and to paſs it by means of an epaulement. In both ways he may ſufficiently be obſtructed, to be diſheartened. But ſuppoſe he arrives to the body of the work, a principal gallery with

with liftners, placed behind the fcarp, will render his fuccefs impoffible.

The prefent practice is, that the enemy advances to the covert-way by means of covert-faps, that is, by underground galleries, leaving only half, or a foot of earth over their heads; then throwing down this head, their lodgments are almoft quite finifhed. Nothing is more eafy than to ftop this work, and to oblige the enemy to proceed in another manner, if thought proper.

From thefe general hints of countermines it appears what may done, when joined to a proper conduct of the garrifon, which may and fhould, by a well-regulated conduct, contribute to the entire deftruction of the enemy, in taking advantage of all the diforders he is put in, by the effects of countermines. It muft be confeffed, that this is the beft, and perhaps the only defence, from which fuch great advantages can be made.

As we have not as yet heard or feen a defence of this nature, what I have faid in favour of countermines, may perhaps appear a mere imagination; yet I advance nothing but what is grounded on theory and confirmed by experience; it is matter of fact, and I not only can affert the poffibility, but likewife the eafinefs of its execution.

No countermines I have feen, in the feveral attacks I have been at, were difpofed in a proper manner, nor all the advantage made of them, if properly exerted. It is true, that thefe advantages depend on fuch mechanical principles as are taught by geometry, which few miners are acquainted with.

I muft own, that 15 or 20 miners commonly fent into a place befieged are by no means fufficient; for the moft that they can do, is to make a few mines here and there under the glacis, which only frightens the enemy without doing any great harm; the little time that is gained by them is not worth mentioning. Befides, for want of communications, the mines muft be charged at the approach of the enemy to the covert-way, which is a great difadvantage; to this I may add, that if the num-

ber of miners were greater, if their works are not begun before the ſiege, the ſituations are oft ſuch, that very little reſource can be expected from them.

To prepare ſuch countermines as I propoſe, requires time and expence, but neither are ſo conſiderable as might be imagined: in 3 or 4 months, if no rock intervenes, a place may be ſufficiently countermined, as far as 60 or 70 fathom from the covert-way, ſuppoſing a ſufficient number of workmen. As to the expence, it is a mere trifle, in compariſon to the many millions of livres the fortification of a place coſts, to preſerve which requires all the care and precaution that is poſſible; for in a front of a polygon of 200 fathoms, I ſuppoſe requires 2000 fathoms of galleries, which may perhaps coſt 35000 livres in materials and workmanſhip, and 100,000 lb. of powder in reſerve for that uſe.

It muſt be obſerved, that if ſuch a work be undertaken, it ſhould be carried on with all ſpeed, and without intermiſſion; all the parts of a place, ſuſceptible of making mines, ſhould be finiſhed together, for it would be dangerous to be attacked in a front not prepared, whilſt all the others are; it will beſides inſtruct the enemy of your condition, which he always diſcovers too ſoon.

The ſcience of countermines has a ſuperiority over that of fortification, becauſe the latter is partly arbitrary, whereas the former is determined by the ſituation of the works and nature of the ſoil: another advantage the mines have, no leſs conſiderable than the former, is, that the poſition of theſe mines may be ſo varied, as to be impoſſible for the moſt experienced enemy to gain any intelligence of them.

The galleries ſupported with wood, are eaſier defended, and more commodious to avoid certain accidents, than thoſe made of maſonry; but as wood decays, it is more convenient to make thoſe galleries, which are to ſtand a conſiderable time, with maſonry, by obſerving however to make the roof flat, inſtead of round as they are commonly made, to prevent certain accidents. As to the objections which may be made againſt this method of making

making countermines; the moſt material is, that the miners cannot enter thoſe galleries filled with ſmoke ariſing from the ſpringing of a former mine, which ſuffocates them; but theſe, and other inconveniences, may be avoided, by a particular conſtruction of theſe galleries, which purifies the air, and makes it circulate*.

## General Conſtruction of the ſeveral Stages of Countermines.

Fig. 18, in the line g H, repreſenting the ſlope of the glacis, take the line g F, equal to 4, 5, or 6 feet, for the thickneſs of earth to be left to ſerve as a parapet to the covert-way: take F z, equal to half the diameter of the excavation, and z O, the perpendicular to F H to the line of leaſt reſiſtance; then the line F L will repreſent the ſection of the plane in which the ſeveral ſtages of countermines are placed. In order to find the diſtances of the chambers in that plane, take O M, M L, each equal to F O, and the points O, M, L, will repreſent the centers of the chambers: this may be carried on to any depth. This conſtruction is evident from M. Belidor's principles, that the charges of mines are proportional to the cubes of the radii or lines O F, M O, L M, of the globe of compreſſion.

M. Valliere will have the line M O always equal to the line of leaſt reſiſtance, O z, of the mine next above it; but obſerves, that in a ſoil of an uniform denſity, experience ſhews that theſe lines are to be increaſed by one third of the line of leaſt reſiſtance; ſo that if the line

* What this particular conſtruction of galleries, which M. Valliere mentions here, is, remains as yet a ſecret; nor can it be gueſs'd at: for if he means that air-holes may be made from diſtance to diſtance, they may be diſcovered from above, and either ſtopped, or ſome ſtinking compoſition thrown through them into the galleries, and thereby increaſe inſtead of diminiſhing the danger: or whether, the galleries, by having ſeveral entrances, and a communication with one another, can be freed by this means from the ſulphurous ſmoke, ſoon enough to be entered and defended when required, can, in my opinion, only be known from experience.

line of leaſt reſiſtance O z is 12 feet, O M ſhould be 16; which anſwers our conſtruction nearly. He ſuppoſes likewiſe in his conſtruction, that the diameter of the excavation is always double the line of leaſt reſiſtance; but we have proved, that it may be triple or quadruple of that line. It is therefore neceſſary in this conſtruction to determine the ratio of the lines F z and z O, from the charge, to determine the plane F L of the ſeveral ſtages of mines.

Fig. 19. ſhews the diſpoſition of the chambers of the countermines, in a ſection of the glacis parallel to the covert-way; and how they ſhould be placed under each other.

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## Explanations of the Figures.

### PLATE I.

Fig. 1. Shews the figure of an excavation.

Fig. 2. Shews how the ſame battery has been blown up 3 times by 3 mines C, D, E, placed below each other.

Fig. 3. Shews the plan of the galleries and chambers.

Fig. 4. Profil of the ſame mines lengthways of the battery.

Fig. 5. Shews how a battery is blown up once only.

Fig. 6. The plan of the galleries of the preceding mines.

Fig. 7. Plan of mines conſtructed at Biſy, to ſhew the effect of the globe of compreſſion.

E. Chamber, whoſe line of leaſt reſiſtance was 12 feet, and loaded with 3000 lb. of powder.

I F. Gallery 69 feet long, going from the bottom of the pit I, and paſſing 14 feet under the chamber E.

H G. Branch from the gallery, 14 feet lower, and 8 diſtant from the chamber E.

Fig. 8. Section thro' B A, paſſing thro' the chamber E.

Y Z X. The gallery going from the pit I, ſloping 18 inches from Y to Z, the reſt being level.

V. T. Horizontal line, and O N the ſlope of the ground of 5 feet from the gallery A to the gallery B.

R S. A perpendicular of 26 feet.

Fig. 9. Section thro' D C of the plan paſſing likewiſe thro' the chamber E, and the galleries D, C.

PLATE

## PLATE II.

Fig. 10. 11. Shewing the extent of the excavation made by the chamber E, fig. 7, and the parts burſt of the high and low galleries.

Fig. 12. The plan of a place of arms D in a covert-way, countermined.

Fig. 13. The ſame place of arms, as appeared when the galleries were blown up, to make trenches.

Fig. 14. The ſame as the two former, only cleared and traverſed, to prevent being enfiladed.

Fig. { 15. } A ſection of the 13th figure.
Fig. { 16. } A ſection through the 14th figure, formed into ſteps.

## PLATE III.

Fig. 17. Shews the plan of an attack of a place countermined. The great circles, I, repreſent the effects of the globes of compreſſion; and the little circles the countermines ſprung by the beſieged to blow up the advanced ſaps of the beſiegers.

*FINIS.*

# A Scheme to improve Artillery,

## For Sea and Land Service.

THE indiſpenſable neceſſity of having a very large Artillery, for Sea and Land Service, and the extraordinary expence attending it, induces me to hope that this propoſal for reducing the weight and expences, may be acceptable; eſpecially as no nation have as yet made any ſuch attempt.

This is to be conſidered under two heads: the one to diminiſh the weights; and the other not to uſe any braſs field artillery, but only iron; to leſſen the great burthen of our ſhips of war, and to carry larger calibers than thoſe of other nations of the ſame rate. If the weights of our guns are diminiſhed, they will require fewer hands to manage them, and of conſequence, a ſmaller number will be expoſed to danger at a time: and if we carry larger calibers, our rates will be a match for larger ſhips.

The advantage of uſing iron guns in the field inſtead of braſs, will be that the expences are leſſened in proportion to the coſt of braſs to that of iron, which is as 8 to 1.

The only objection againſt iron is, its pretended brittleneſs: but as we abound in iron, that is ſtronger and tougher than any braſs, this objection is invalid. This I can aſſert: having ſeen ſome that cannot be broke by any force, and will flatten like hammer'd iron: if then we uſe ſuch iron, there can be no danger of the guns burſting in the moſt ſevere action.

Though braſs guns are not liable to burſt, yet they are ſooner rendered unſerviceable in action than iron. For by the ſoftneſs of the metal, the vent widens ſo ſoon, and they are liable to bend at the muzzle, that it would be dangerous to fire them; as we have found by experience at Belleiſle, and where we have been obliged to take guns from the ſhips to finiſh the ſiege.

Theſe being undeniable facts, no poſſible reaſon can be aſſigned againſt uſing iron guns in both ſea and land ſervice, and thereby leſſen the expences of artillery, ſo conſiderably as will appear by the following tables:

Length

### Length and Weights of Iron Ship Guns.

| OLD PIECES. Calib. | Length Ft. | In. | Weight | | | NEW PIECES. Calib. | Length Ft. | In. | Weight | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 4 | 6 | 7 | 1 | 7 | 3 | 3 | 6 | 3 | 3 | 0 |
| 4 | 6 | 0 | 12 | 2 | 13 | 6 | 4 | 4 | 7 | 2 | 0 |
| 6 | 7 | 0 | 17 | 1 | 14 | 9 | 5 | 0 | 11 | 1 | 0 |
| 9 | 7 | 0 | 23 | 2 | 2 | 12 | 5 | 6 | 15 | 0 | 0 |
| 12 | 9 | 0 | 32 | 3 | 3 | 18 | 6 | 4 | 22 | 2 | 0 |
| 18 | 9 | 0 | 41 | 1 | 8 | 24 | 7 | 0 | 30 | 0 | 0 |
| 24 | 9 | 0 | 48 | 0 | 0 | 32 | 7 | 6 | 40 | 0 | 0 |
| 32 | 9 | 6 | 53 | 3 | 23 | 42 | 8 | 4 | 52 | 2 | 0 |
| 42 | 10 | 0 | 55 | 1 | 12 | 48 | 8 | 6 | 60 | 0 | 0 |

Guns of this construction appear sufficiently strong from the proof of two three-pounders, made for Lord Egmont, and that they may even be made lighter and of equal service.

### Length and Weight of Battering Pieces.

| OLD BRASS. Calib. | Length Ft. | In. | Weight | | | NEW IRON. Calib. | Length Ft | In. | Weight | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 8 | 0 | 19 | 0 | 0 | 6 | 6 | 1 | 9 | 1 | 0 |
| 9 | 9 | 0 | 25 | 0 | 0 | 9 | 7 | 0 | 14 | 0 | 0 |
| 12 | 9 | 0 | 29 | 0 | 0 | 12 | 7 | 8 | 18 | 0 | 0 |
| 18 | 9 | 6 | 48 | 0 | 0 | 18 | 9 | 0 | 29 | 1 | 0 |
| 24 | 9 | 6 | 51 | 0 | 0 | 24 | 9 | 8 | 37 | 3 | 0 |
| 32 | 10 | 0 | 55 | 2 | 0 | 32 | 9 | | 42 | 0 | 0 |
| | | Total | 227 | | | | | Total | 151 | 0 | |
| | | | | | | | | Diff. | 76 | 2 | 0 |

That

That theſe guns are ſufficiently ſtrong, is evident from the former trial; beſides, there are ſeveral 32 pounders of the ſame dimenſions and weight now exiſting and ſerviceable, though caſt in King Charles the Second's time.

N. B. Theſe battering pieces may ſerve in Garriſons.

It appears from theſe tables that no proportion has beeen obſerved in any guns hitherto made, in reſpect to their length or weight, but merely by gueſs.

*Some examples to ſhew what may be ſaved by this ſcheme.*

The Royal George carries a hundred braſs guns, which weigh together 218.2 tons, the ton coſt 130 pounds, workmanſhip included.

| | |
|---|---|
| The expence of theſe guns is then - - | 28366 pounds |
| A ſet of the iron guns of the ſame number and calibers, according to my conſtruction, weighs | 127.8 tons |
| The ton coſt 16 pounds, and the whole ſet | 2044.8 pounds |
| The Royal George carries then 90.4 tons more than is neceſſary, and the difference between the expence is | 26321.2 pounds |

That is 12.5 times more than the new iron ſet coſts: or twelve ſhips of the ſame rate may be fitted out leſs charge.

| | | | |
|---|---|---|---|
| A ſet of the Old | irons guns for a firſt-rate weighs | 204.4 | tons |
| A ſet of the New | irons guns for a firſt-rate weighs | 127.8 | tons |

| | |
|---|---|
| The difference betwen the weights of the old and new is | 76.6 tons |
| The difference between the expence is then | 1225.6 pounds |
| A ſet of braſs battering pieces weighs | 11.36 tons |
| A ton coſt 130 pounds, and the ſet | 1476.8 pounds |
| A ſet of the new weighs - - - - - | 7.55 tons |
| The ton coſts 16 pounds, and the ſet | 117.8 pounds |

That is 11 times, and 632 over, more than the new ſet, or eleven ſets of the new, could be made at leſs expence than one of the old.

The

This table ſhews what may be ſaved in the Navy; and if we add thoſe on board ſloops, the different garriſons, and the field train, with the great expence of their carriage in the field, it may be found pretty near as much more.

| Numb. of Guns. | Weight of Old. | | Weight of New. | | Differ. | | No. of Ships. | Total Difference | |
|---|---|---|---|---|---|---|---|---|---|
| 100 | 4367 | 3 | 2556 | 0 | 1811 | 3 | 5 | 9058 | 0 |
| 90 | 3537 | 3 | 2001 | 0 | 1536 | 3 | 9 | 13827 | 3 |
| 80 | 3108 | 3 | 1827 | 0 | 1287 | 3 | 7 | 9014 | 1 |
| 74 | 3091 | 0 | 1840 | 2 | 1250 | 2 | 32 | 40016 | 0 |
| 70 | 2997 | 0 | 1796 | 2 | 1200 | 2 | 10 | 12005 | 0 |
| 64 | 2543 | 3 | 1305 | 0 | 1238 | 2 | 23 | 28485 | 2 |
| 60 | 2177 | 3 | 1185 | 0 | 972 | 3 | 30 | 29782 | 2 |
| 50 | 1881 | 1 | 1035 | 0 | 846 | 1 | 19 | 16078 | 3 |
| 44 | 1365 | 2 | 705 | 0 | 660 | 2 | 8 | 5284 | 0 |
| 40 | 1234 | 2 | 312 | 2 | 922 | 0 | 9 | 8298 | 0 |
| 36 | 963 | 3 | 450 | 0 | 513 | 3 | 7 | 3596 | 1 |
| 32 | 956 | 2 | 435 | 0 | 521 | 2 | 28 | 14602 | 0 |
| 28 | 593 | 2 | 285 | 0 | 308 | 2 | 23 | 7095 | 1 |
| 24 | 531 | 3 | 255 | 0 | 276 | 3 | 12 | 3321 | 0 |
| 20 | 421 | 2 | 191 | 1 | 230 | 1 | 15 | 3453 | 3 |

Difference between the Weights - - - - - 203918 3 0

Expences of the { Braſs guns of two firſt rates, — 203918 15 0
Iron ditto — — — 53109 5 0

We get £. 257028 0 0

If then no material objection can be made to this propoſal, ſo beneficial to the nation, I humbly hope that it will be put in practice, and that my trouble of compoſing it, after above fifty years application, to theory and practice, will be conſidered.

JOHN MULLER.

Proportion of Ammunition for the following Troops, being the Extra Allowance for one Year, commencing the 25th of March, agreeable to King's Warrant, 1760.

| | | Powder. | Ball. | | | Flints. | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mufqt. | Carbine. | Piftol. | Mufqt. | Carbine. | Piftol. |
| | | Barrels. | C. | C. | C. | No. | No. | No. |
| A Regiment of Foot of 900 Men for - | Service | $13\frac{1}{2}$ | 35 | | | 2700 | | |
| | Exercife | 19 | 11 | | | 1800 | | |
| A Regiment of Dragoons of 360 Men for | Service | 5 | 9 | | 2 | 1134 | | 2268 |
| | Exercife | 7 | 1 | | | 756 | | 1512 |
| A Light Troop of 121 Men for - - - - | Service | $2\frac{1}{2}$ | — | 7 | | | 363 | 393 |
| | Exercife | $11\frac{1}{2}$ | | | | | 242 | 262 |

N. B. The

N. B. The proportion of ammunition for a regiment of foot is 64 rounds for each man for ſervice, at 6 drachms each cartridge, and 135 rounds each man for exerciſe, at ¼ of an oz.

Muſquet flints, 3 to each man for ſervice, and 2 for exerciſe.

Muſquet balls, 20 to each man for exerciſe.

The proportion for a regiment of dragoons is one pound of powder for ſervice, and two pounds for exerciſe to each man; each cartridge to contain the ſame as thoſe of the foot.

The proportion for the light dragoons is 64 rounds for each man for ſervice, at ¼ of an oz. each cartridge, and 405 rounds each man for exerciſe, at 3 drachms each cartridge.

The battalions of militia embodied are to have the ſame proportion of ammunition as a regiment of foot, according to their numbers.

*Office of Ordnance, May* 14, 1760.

## Form of a Certificate for Ammunition to be addreſſed to the Right Hon. and Hon. the Board of Ordnance, whenever a Supply of Ammunition is wanted.

THESE are to certify the Right Honourable and Honourable the Board of Ordnance, that the laſt Supply of Ammunition received for Uſe of Regiment of or Company of under the Command of is nearly expended in the Duty and Exerciſe of the ſaid Witneſs my Hand this Day of

*To the Rt. Hon. and Hon. the Board of Ordnance.*

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3 Bradley's Lectures, 3s.
4 Barrow's Medicinal Dictionary, 8s.
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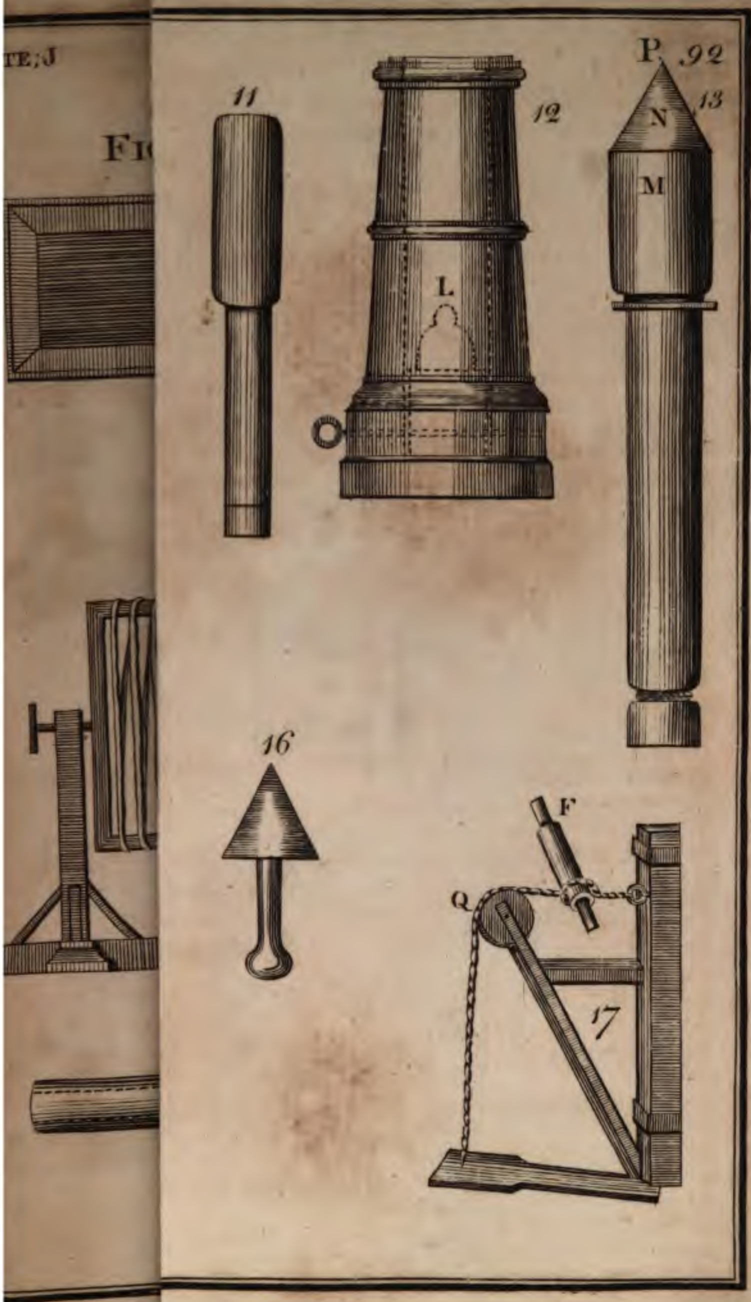
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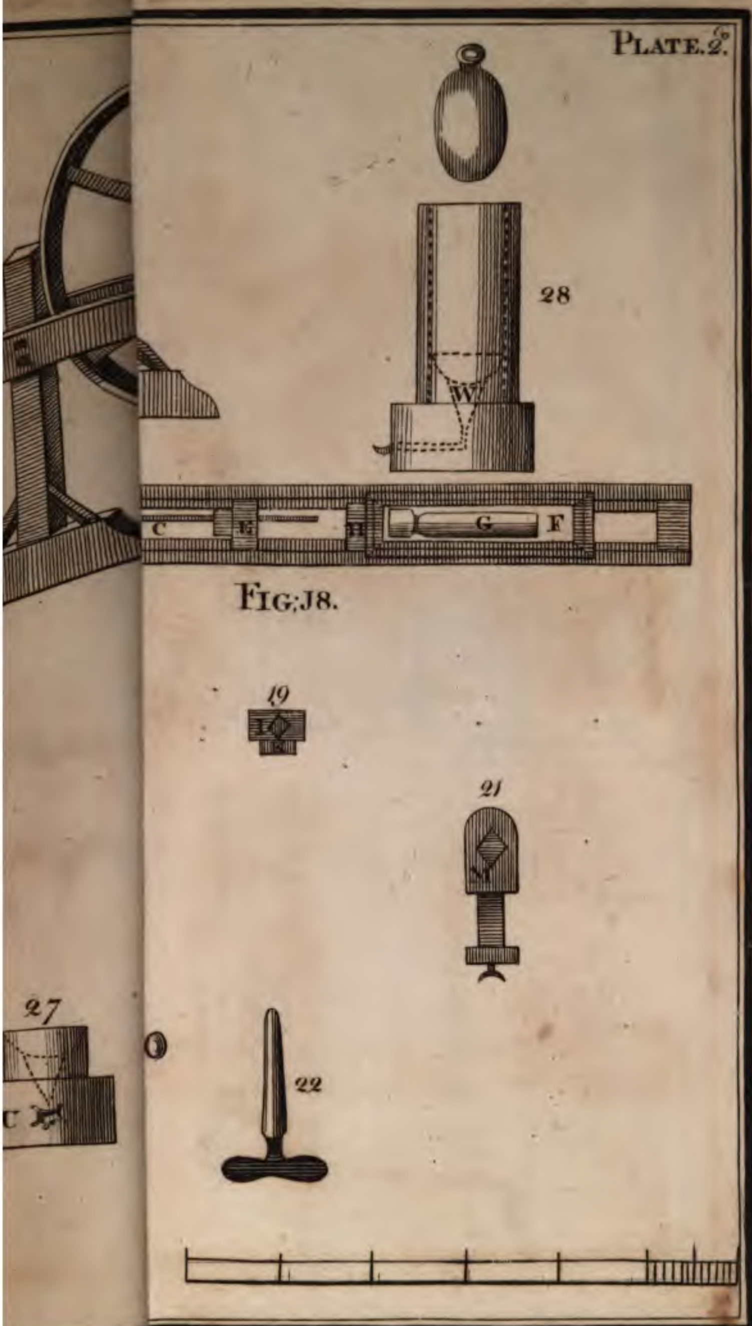

PLATE. 2.
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FIG; 18.
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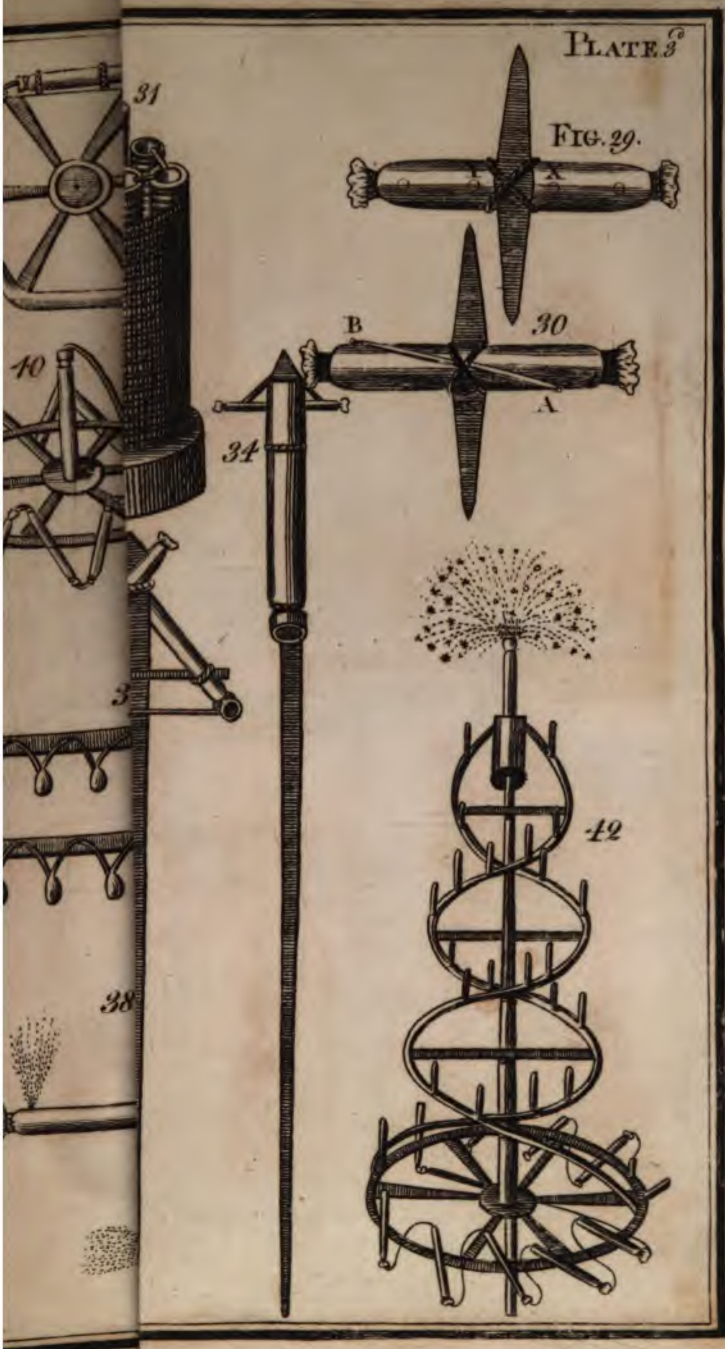
PLATE 3
FIG. 29.
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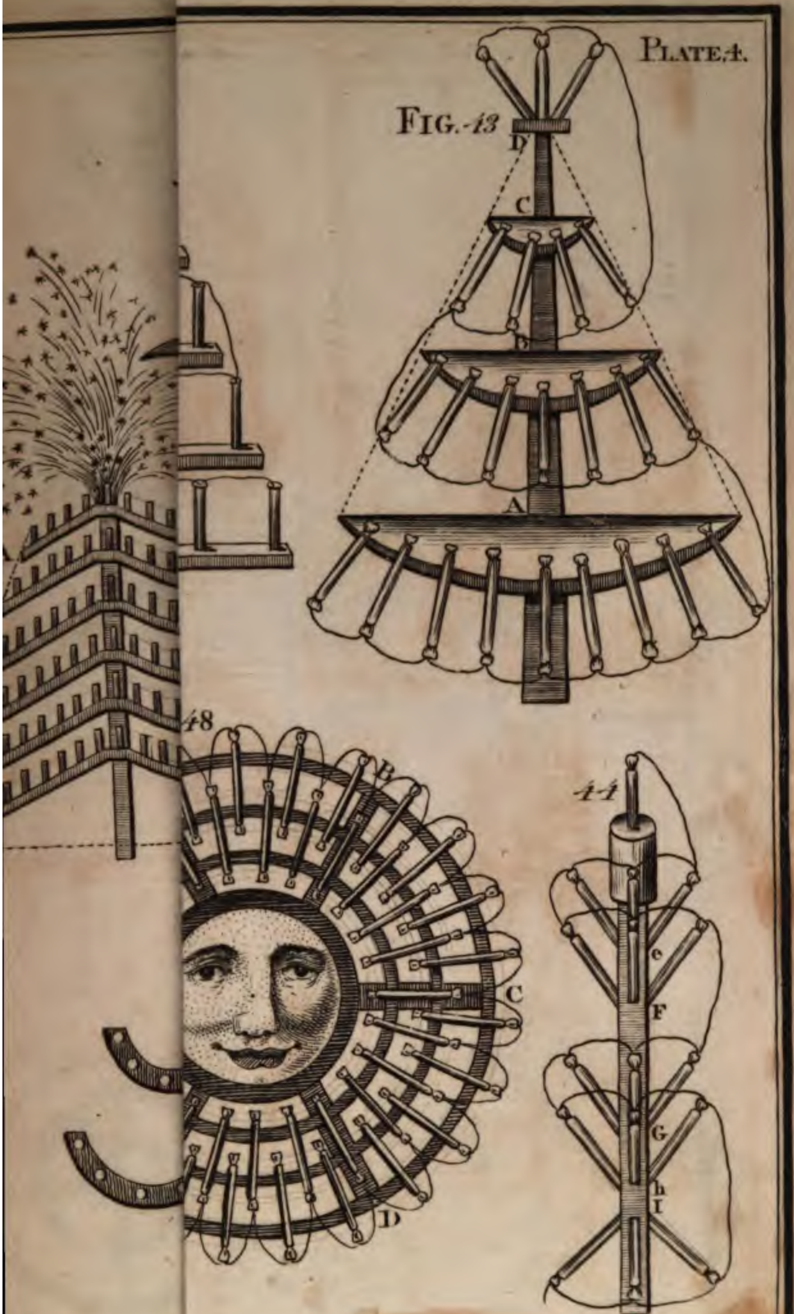

PLATE 4.
FIG. 43
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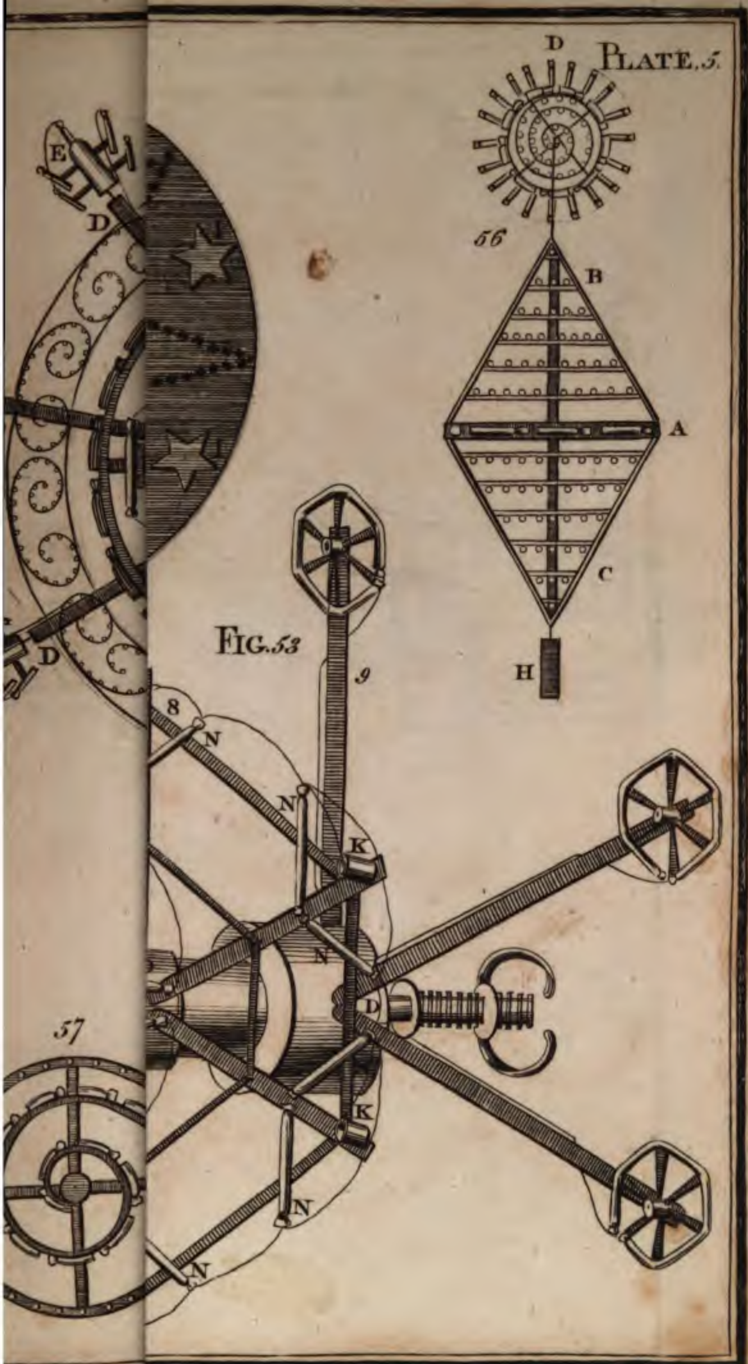
PLATE. 5.
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FIG. 53
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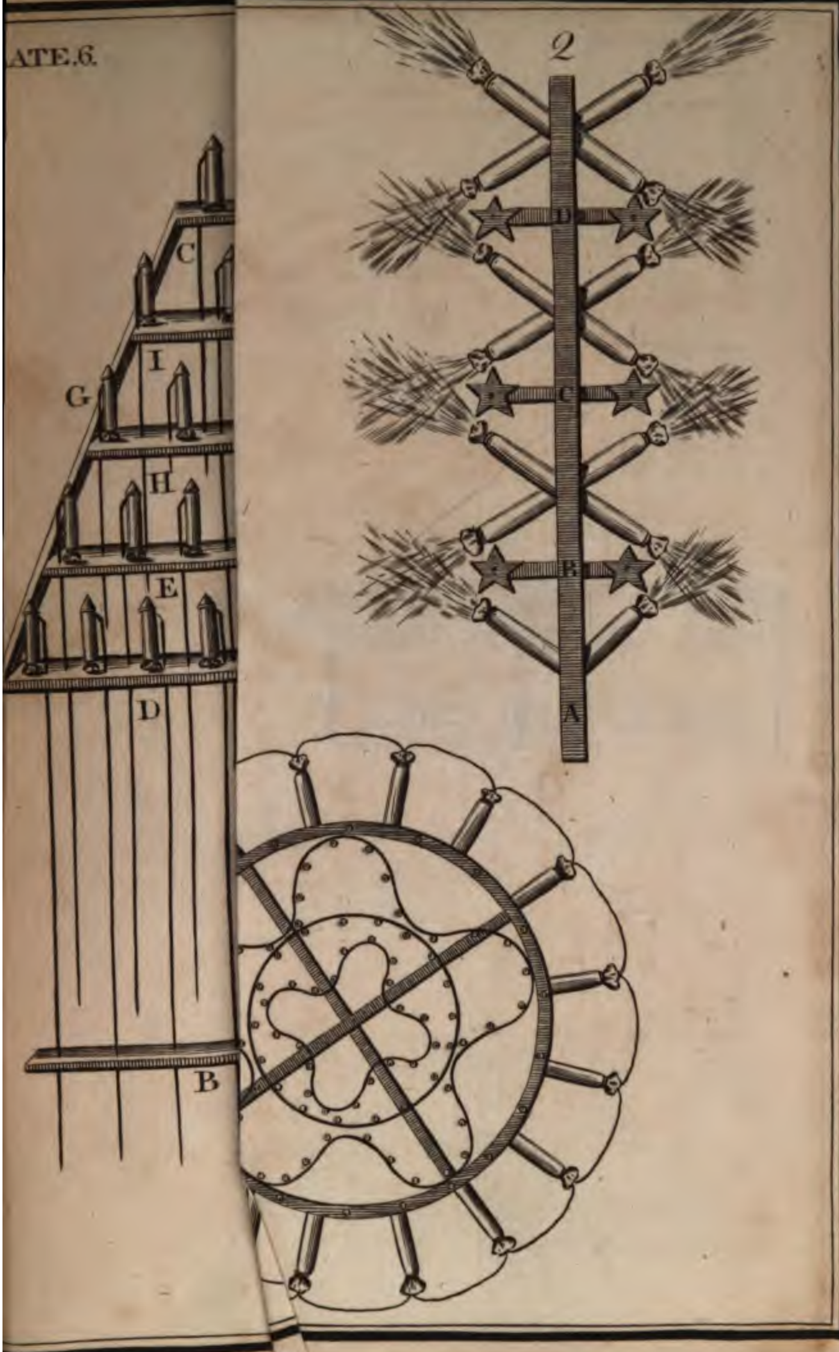

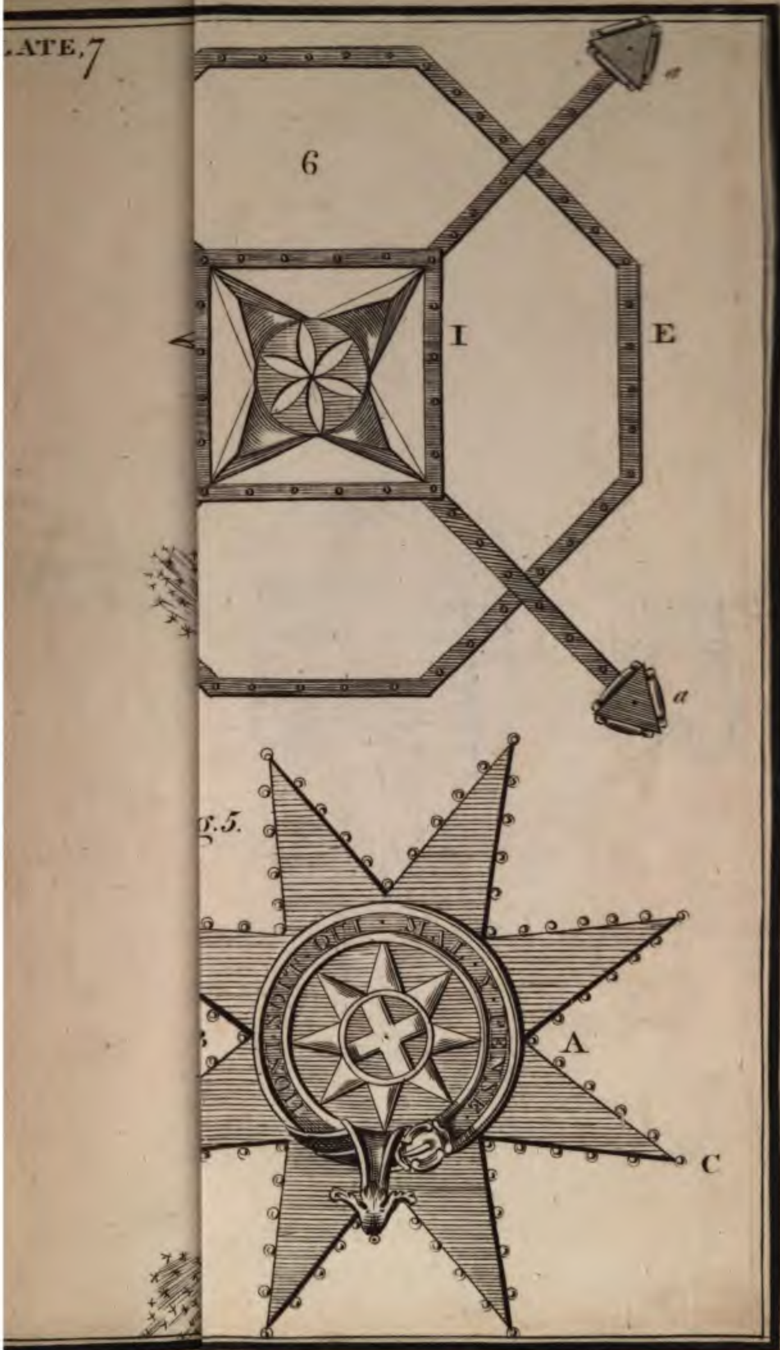
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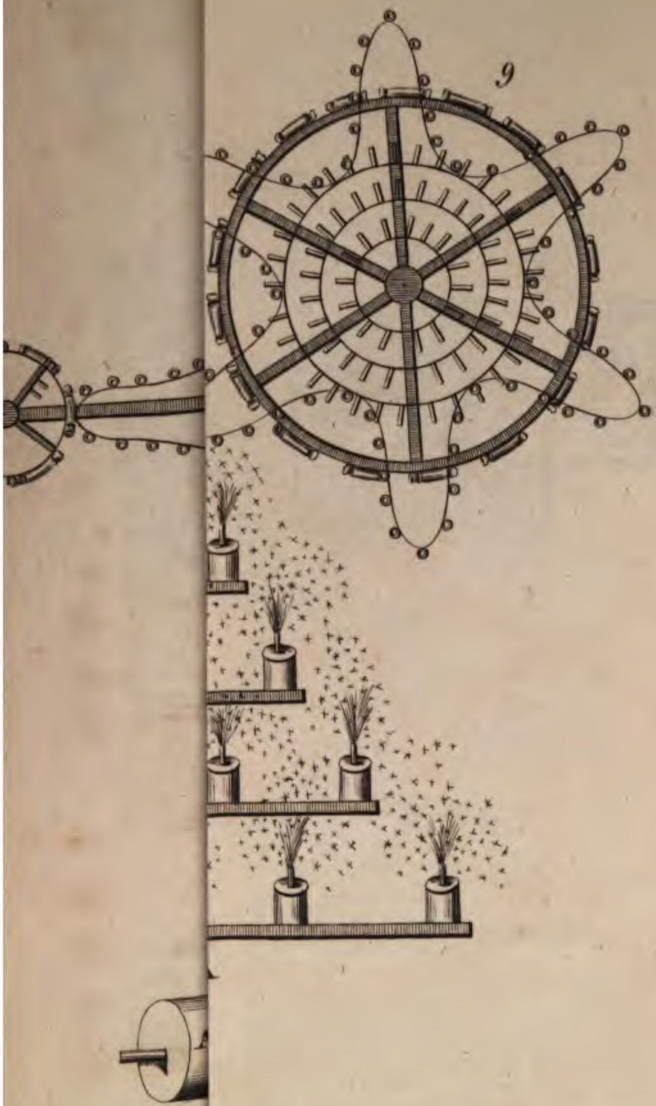


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